HOUSE OF LORDS SESSION 1996–97

MINUTES OF EVIDENCE
TAKEN BEFORE

THE SELECT COMMITTEE ON SCIENCE AND TECHNOLOGY

THE INNOVATION-EXPLOITATION BARRIER

Ordered by The House of Lords *to be printed 11 March 1997*

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CONTENTS

CALL FOR EVIDENCE

The House of Lords Science and Technology Committee has appointed Sub-Committee II, under the chairmanship of Baroness Hogg, to conduct an enquiry into the Innovation-Exploitation Barrier. This will be a follow-up enquiry to our earlier report on Innovation in Manufacturing Industry, published in 1991. It is being carried out in the context of the Bank of England report on *The Financing of Technology-Based Small Firms* (October 1996) and the conference on this subject to be organised by the Bank of England, the CBI and the Royal Society in early 1997. We will receive evidence in writing and in person, with a view to making a report to the House of Lords in 1997.

The Sub-Committee invites written submissions on matters of relevance to this topic, but in particular on the questions listed below. The enquiry will focus on how innovative ideas from our science and technology base are turned into exploitable products or processes for the United Kingdom. We wish to assess the effectiveness of the innovation initiatives promoted by the Department of Trade and Industry and their impact on start-up companies. One of the main areas on which we wish to concentrate is the early phase of development of technology-based firms, including their access to funds and management support. We ask the question, to what extent does the United Kingdom suffer from an inability to exploit its own developments in science and technology and what can be done to address this problem?

1. What is the current state of innovation in the United Kingdom?
2. How successful have the Department of Trade and Industry (DTI) and other Government Departments been with their range of initiatives designed to stimulate innovation?
3. How effective in terms of product or process innovation and other exploitable outcomes are initiatives which encourage collaboration between industry and academia?
4. Does financing need to be improved for technology-based small firms during their crucial start-up and early development phases?
5. What other support systems could be introduced to ensure that the maximum advantage is taken of innovative ideas that originate with individuals or, for example, in academia?
6. Is there institutional inertia towards the funding of technology-based small companies? If so, to what extent may this be due to financiers' unfamiliarity with science and technology concepts and what should be done to address this?
7. The Committee recommended tax credits for research and development in our previous enquiry. Would this still be an effective way of fostering innovation and how should they be introduced to ensure that they are roughly cost-neutral?
8. How has the Technology Foresight Exercise influenced the availability of development funds for innovative ideas that were not given short-term high priority status?
9. Has the tax relief introduced in 1992–93 for individuals' expenditure on vocational training had any impact on the status of continuing professional development, in particular for employees in small firms?

MINUTES OF EVIDENCE

THURSDAY 5 DECEMBER 1996

Present:

Cuckney, L.
Dainton, L.
Dixon-Smith, L.
Hogg, B. (Chairman)
Winston, L.
Kirkwood, L.

Examination of witnesses

DR DAVID EVANS, Director, Technology and Standards, DR ALISTAIR KEDDIE, Director, Innovation Unit, and MR JOHN BARBER, Director, Technology, Economics, Statistics and Evaluation, Department of Trade and Industry, were called in and examined.

Chairman

1. Dr Evans, may I start by welcoming you to the Committee and thanking you for responding so promptly to our request that you come and give oral evidence.

(*Dr Evans*) The subject of innovation is extremely important and dear to the heart of the DTI and we are very pleased to be able to assist the Committee in answering questions. On my right is Dr Alistair Keddie, who is head of the Department's Innovation Unit, which is a relatively small unit composed of civil servants and industrialists which has as its mission the promotion of innovation and more and better innovation in the economy. On my left is John Barber who heads the branch in my Directorate, (the Technology and Standards Directorate) that looks at technology, economics and statistics issues and I hope he will be able to help us with questions of that nature. I think perhaps a reasonable way to start would be on the first general question you posed which was about the current state of innovation in the United Kingdom.

2. Thank you.

(*Dr Evans*) The first point that I would like to make about that is that we have not found it possible to devise a single measure or a single index of innovation which can apply to the economy as a whole or indeed to individual companies. The definition we have of innovation, which was developed by the Innovation Unit, is "the successful exploitation of new ideas". So it is not just about doing research and development; it is not just about getting hold of new technologies; it is the whole chain which goes from the original idea (which can be a technological idea or some other kind of idea or other kind of innovation) through to its successful development, its marketing, its implementation in the sense of manufacturing of a product or, if it is a process, the successful development and training of the people who might be involved in that, through to success in the market-place. So we have not found a single measure in the same way that you can say in relation to inflation the number is 2.3 or whatever. However, there are a number of indicators we can use to help ourselves assess the state of innovation in the economy. Some of these are to do with the things I have mentioned already like the rate of investment in R&D within firms and in the public sector in the economy. Also there is a certain amount of information which can be obtained from statistical surveys of companies, particularly statistical surveys of small and medium-sized companies who play a particularly prominent role in innovation in the economy as a whole. There are other ways we can assess innovation in terms of the attention it gets in the media and press and indeed the attention which your own Committee is giving to the subject and I think our broad assessment is that innovation is much more on the agenda than it was three or four years ago, that in the language of business more attention is being given to the need to change, to improve, to develop than it was. The same thing appears in company reports to a greater extent than it did before. It is something which Training and Enterprise Councils in their activities in trying to improve the workforce are paying more attention to. In general I think there are more press articles about the whole subject and the financial press has paid more attention to the need for companies to innovate if they are to be successful. Some work which was done with the assistance of the Innovation Unit looked at the relationships between companies and their investors and tried to set up some best practice which I think included the need to think about innovation in these areas. If we look at other areas of importance to innovation, the relationship between companies and our science base, sources of technology in the United Kingdom, not all technology comes from our universities or research institutes but there has been a steady growth in the interaction between industry and the universities. I think that is on a positive trend. And I think there is also a positive response to the Technology Foresight programme from a wide range of different firms. All of these things indicate that the consciousness of innovation is on an upward trend and we are doing better than we were a number of years ago. That does not mean the problem is a solved problem and I think there are other indications that yet more needs to be done. When we look at the surveys done by a variety of academic institutions on companies we find that characteristically the population of firms in the United Kingdom has a good representation at the very top end of the spectrum. When we look for world-class companies we have roughly the same representation of world-class companies in the UK as you find in France or Germany. What we seem to have more of is more mediocre performance. The bottom end, the tail, is longer and performing less well than in other countries we might wish to emulate and that is an example of how we need to do some

Chairman *contd.*]

more work and that is an area where innovation needs to penetrate further into the culture of the companies. Overall it is a bit like a school report; it is doing quite well but could do better.

3. Any other initial remarks your colleagues would like to make?

(*Mr Barber*) Only on the question of skills. The sectors in which the United Kingdom is weak tend to be the more traditional sectors of the economy where we tend to do less R&D in relation to output than our foreign competitors. These are also the areas where we tend to be weak in skills at the technician and craftsman level. In other words we did not carry the Industrial Revolution through to the very high level of skills that the Germans have.

Lord Winston

4. Could you give an example?

(*Mr Barber*) I think the best examples came from a series of surveys that the National Institute of Economic and Social Research did in comparing practices in similar factories in Germany and the UK. The examples they came up with, scheduling of outputs in factories in United Kingdom firms tended to be less good, cases of machines left on default settings because nobody knew how to make them work properly, these kind of examples. The equipment was often as new in the United Kingdom but was less sophisticated and they were less well able to use it. The return from bringing in a new machine was lower and so of course they innovated less.

Chairman

5. How do your policies tie in with DfEE policies to do something about this?

(*Mr Barber*) I think we have had a number of schemes which in the past have helped firms, for example, to improve the organisation of their production. We run a number of schemes whereby we take examples of best practice in industry and communicate them to a much wider range of firms so the poorer performers can learn from the better performers. Skills is primarily a matter for DfEE, but we do a lot to try and bring to industry's attention where it can improve and provide examples for them to follow.

(*Dr Keddie*) Increasingly, where we are developing or identifying new areas of best practice we will involve the Department for Education and Employment. We also involve the Training and Enterprise Councils from the very beginning so they are part of the emergent conclusions and they all know them and therefore they become part of DfEE policy as well.

(*Dr Evans*) I think the trend which I would point to in this area over the last four or five years is the increasing convergence between the DTI and the DfEE's attention to this area. We can give an example in the way we have developed our business links with these "one-stop shops" throughout the country where we have worked to create a coalition of interest between the local Training and Enterprise Councils, the chambers of commerce and, where they exist, the local authority economic development agencies to provide business support on a local basis, to address in a more sympathetic way the whole spectrum of problems facing a particular firm. It was a conscious decision that the infrastructure we have tried to put in place for the Business Links should build out from the Training and Enterprise structure which has been created by the DfEE. That is not to say we are doing exactly the same job because I think we come at it from a particular DTI perspective which is to do with our knowledge of the sectors, the competitive analyses which we have done of particular sectors, our particular responsibilities for the science and technology base. The Office of Science and Technology, which funds research councils, is part of the DTI, therefore we have close and good working relationships. We work very closely with the Office of Science and Technology in developing programmes so that we can bring to bear our perspectives on these problems which complement and, in my view, increasingly converge on the same problems from different directions.

6. If we come back to your initial profile of this process of innovation where you say that it is not easy to produce indicators in the way you can, for example, in counter-inflationary policy, if you were to weigh up the contributory factors against each other would it be money, the transfer of people or some other factor that you consider to be the main route for success in stimulating innovation or creating innovation and subsequent development of new products and processes?

(*Dr Evans*) I think the introduction I gave tried to portray the argument that there is a whole chain of factors which will lead to successful innovation and therefore I think it is wrong to point solely to the availability of money as being a crucial issue for improving the United Kingdom's innovation performance. That is not to say that the availability of finance for companies is not an important aspect; it certainly is. There was actually a very interesting recent report by the Bank of England which did some very interesting analyses of the financing of innovation and made a number of recommendations for different kinds of action. As Dr Keddie was involved in that report, maybe he would like to say something about it.

(*Dr Keddie*) I think the first thing to say about the report is that of course it was dealing specifically with start-up, emerging and technology-based growth businesses. The issues are similar across the whole spectrum of size but that particular report was focused on the smaller end. It is certainly the most comprehensive and recent analysis of the situation in the UK. It very helpfully includes comparisons with other countries including the US, Germany, France and Japan and I think it is fair to say that we would subscribe to the broad analyses and conclusions in the Bank of England report. What it does highlight is that, yes, finance is important, it is the source of resource if you like in many respects, but unless the individual or the team which is coming forward with the proposition for funding has got the management, commercial and marketing skills as well, or knows how to access these, then it is unlikely that that investment will be successful. So in a sense what we are seeing, if you like, is the market-place responding

Chairman *contd.*]

fairly rationally to the sorts of propositions that come to it. It can be very exciting in technological terms but if the individuals do not understand the marketplace or don't have the right contacts in the market place it is unlikely to be a success.

Chairman] That report was indeed one of the stimuli for this enquiry, the request for a wider debate.

Lord Kirkwood

7. Part of the question was about transfer of people. It is often claimed that it is transfer of individuals or research teams from research institutes to small companies or large companies that is the barrier. Would you support that?

(*Dr Evans*) Yes, I think that does go to the heart of the issue. When we try and analyse the population of United Kingdom firms, which we have done in various surveys, particularly small and medium-sized companies, and tried to differentiate between those which grow fast and those which do not grow fast, we find there is a general grouping of factors which are associated with the most successful groups and they are associated with connections to the science and technology base, either the university science and technology base or the industrial research and technology organisations. The higher the proportion of the workforce that are qualified scientists and engineers, the more likely it is to be in a group of high growth companies. The more the company consciously differentiates its product portfolio, the more it consciously addresses the innovation issues, the higher its growth is. There is a sort of nexus of positive factors which include openness to the science and technology base. I think it is commonplace that technology transfer is actually something which occurs on the hoof. By far the most effective way of getting technology into a company is actually to get the company to take on somebody who understands the technology, who can apply it in the particular circumstances of that company and can give them the experience to bring that forward to a successful product. We have a range of schemes which are directed at promoting that process; perhaps the most long-lived and successful of these schemes is the Teaching Company Scheme in which graduates who are usually engaged on a postgraduate diploma or masters or something like that spend part of their time working on a real-life problem in an industrial environment in a company, working with that company solving the problem as well as building up the experience and competence to write their thesis and the thesis itself will be on the problem that they solve. That is an extremely effective programme. It has recently been evaluated by a group. It has been running for over 20 years and it has been reviewed every five years and more or less each review has been more positive about the nature of that scheme. That is an example of the positive benefits you get out of transferring people who know about the technologies into companies.

(*Dr Keddie*) The transfer of people, yes, is clearly important for the reasons Dr Evans has said but so also is the investment in the training and skills of the other people in the organisation. You can transfer people in with knowledge and skills but unless the rest of the workforce can also contribute and are given the right sort of encouragement you will not have a successful organisation. Again it comes back to the multifactorial situation. If you isolate one and try and make that a success it is unlikely you will succeed overall. There is a range of factors.

Lord Dixon-Smith

8. I find myself wondering how far we are dealing with what I call general public attitudes. I can well imagine that life in a research institution or life as a researcher in a university, although it has its uncomfortable moments, is a relatively comfortable situation to be in perhaps compared to trying to get out into the harsh commercial word. We went to the United States a year ago where we went to MIT which, it is true, is a rather particular institution and they actually have a dedicated team there looking all the time for opportunities for patents and potential commercial development. I am not aware that we have a similar approach, if you like, to the commercial prospects for intellectual property in this country. I do wonder if what lies behind this whole thing is the fact that there is a much more go-getting atmosphere, environment and tradition over there than we have here. Are we handicapping ourselves through a lack of willingness to take risks?

(*Dr Evans*) I think there is a great deal of truth in that. Many of the differences we see are to do with cultural attitudes and the strength of the American economy derives to a very great extent from the culture of entrepreneurship and entrepreneurial activity. I think you underplay what has happened in the university sector in the United Kingdom in the tone of your remarks. I think universities now are extremely keen on capitalising on intellectual property. Perhaps the pendulum has swung too far in that there is a tendency in universities that anything at all of remote application must be patentable and therefore must be of enormous value and therefore must generate large amounts of money for the Vice-Chancellor to invest (as he must) in order to sustain the excellence of his business. The vast majority of universities now have industrial liaison offices which look at and try to provide a front door for industry to look at the way the capabilities of the university can assist industry and the key function of many of these industrial liaison offices is patenting and protecting the intellectual property. The difficulty about patenting is that it is very very expensive and also it is not worth doing unless you are willing to defend the patent in court—and if you think patenting is expensive you have not seen the cost of defending the patent in the courts. That is not to say you should neglect it because it is a very important issue, it is a key and central business issue, but again it is not the magic key to unlock all of this. The kind of approach that I think is showing success is the kind of collaborative approach where university departments set up long-term relationships so that individual academics or groups of academics and companies can work jointly on projects and they can carry forward both their own academic interests in particular problems with a company and understand

Lord Dixon-Smith *contd.*]

the motivation of the company, what the company really values, what the company would really like to have out of the science base and therefore, where appropriate, direct their research to delivering on those kind of problems. There are lots of examples of that. Rolls Royce has relationships with university departments and I think that works very well in some cases. I think universities have become very hungry for any source of income and they have not neglected the industrial income. That is another indication of the fact that the situation is dramatically different from ten years ago when the universities were much less interested in working closely.

9. It is the most wonderful argument that I have heard so far for keeping the universities short of funds! It might actually mean that something is produced—but that might be a little cynical. Running out of that one flows the question of whether research councils are in fact the most effective route for the distribution of government funds designed to influence innovation and research and development or would a more direct approach, as is the case in Germany where much more of government funding is routed through industry, be likely to be more effective?

(*Dr Evans*) I think this is an issue about the way the infrastructure works. I think my German opposite numbers feel that there are issues about improving the way the German technological infrastructure works in the same way there are issues in the United Kingdom. Although we look in some ways with envy at the way that things happen in Germany I think they see problems with their own infrastructure which we simply do not have because our infrastructures are different. If I might go to the heart of your point, the nature of the task of the research councils is to sustain the research infrastructure in our universities and, as I have said before, it is important that (and it is now a matter of government policy) research infrastructure should assist in wealth creation and in our quality of life and one of the ways of doing that is by working more closely with industry. But in general research council money simply does not go to companies, it goes to universities. It is there to sustain the broad infrastructure, the background to our technological capability. The DTI is still spending roughly £350 million a year in this broad area of science and technology and is more directly concerned with assisting industry, although we have moved from a situation where we felt that the best way of spending money was simply to subsidise R&D in companies much more to a situation where we are trying to direct our money at making the whole infrastructure work better. When I talk about our current innovation policy I tend to say we are working at four different levels. First of all, we are trying to attack the innovation culture which I think relates to a comment you made before; we must promote a stronger, better culture of innovation in the United Kingdom. We are doing this in different ways. The Innovation Unit is very much at the fore in organising the Innovation Lecture which is an annual example, as is the publication of the R&D scoreboard, to try and make more of a public debate about these issues. The second level is best practice in the process of innovation and there we have the activities of Business Links trying to get through to companies how they should actually do the jobs and give them good examples of how they can do the jobs which are associated with innovation more effectively. Thirdly, technology transfer, where we work to a very great extent alongside the research councils but we put money into supplementary programmes which add to what they can do to bring industry closer to the university science base—and the Teaching Company Scheme is one example which I have already mentioned. The Post Graduate Training Partnerships, where we have set up an arrangement under which research and technology organisations can work with universities so that postgraduate students can work in industrial research and technology organisations to get their postgraduate degrees, has been working for three years and seems to be working very well as a way of binding in the industrial research and technology organisations with the science base and improving this flow, giving the connections of the industrial research technology organisations to improve the flow to universities. The fourth level is the traditional area of research and development of new technology where we have the LINK programme where we support collaborations between companies and universities. So, the DTI activity complements the basic funding of the research councils. We think that the whole of the Technology Foresight programme has been very effective in setting out a broad agenda on which the two sides can work more closely together over time. Our broad assessment is that the research councils and other parts of the public sector have been very keen to take up the opportunities identified in the Technology Foresight programme and to work to those priorities. We are less persuaded that the broad mass of industry has paid sufficient attention to the Foresight message, the messages coming from Foresight reports. It was for that reason Mr Taylor, the Minister for Science and Technology, re-launched the Foresight programme yesterday focusing on trying to get the message through to the great mass of companies. I think the short answer is that I do not see it as an either/or. I think we have got our respective roles which we must carry out but we must also work out how to do our respective roles better together.

Lord Dainton

10. As the person who started the first industrial liaison office in this country 30 years ago and was also deeply involved in the Teaching Company Scheme I listen to what you say with considerable interest. As I look back over those years it seems to me there is always a problem that will never be solved and that is the balance within the universities between the basic and applicable in connection with the firm. All the processes are splendid for the present but if you get the balance wrong you pay your debt in the future. By this I mean what George Poste indicated and also you referred to the Innovation Lectures and I think Peter Williams said the real danger we face is that we neglect the science base. That is already diminishing in quality due to lack of equipment, as

Lord Dainton *contd.*]

George Poste clearly points out, which causes a reluctance on the part of industry very often to go and work jointly with the university side. It can be achieved in some cases. Lord Kirkwood will know good examples in Sheffield, I am sure, of this going on but it is becoming more difficult. Would you agree there is always this tension—and you tend to overshoot both ways from time to time? Where do you see the most urgent action now? Whilst you are answering that question (I sound like a DPhil examiner which I have every intention of being!) would you address another problem. It seems to me you used a very significant phrase a short time ago of technology transfer being in a sense ideas "on the hoof" and people moving between them. In the chemical and pharmaceutical industry that arrangement works extremely well for the simple reason that the kind of work a graduate does when he goes into industry is very similar to the kind of work he would do in a university chemical or biochemical laboratory but there are other differences in other subjects that make that less easy. On the whole in this country we have not got the strength which we used to have for the kind of consultancy arrangements and back-transfer of industrial staff teaching in universities. There is a lot of lip service to the latter in the form of visiting professorships but it is pretty feeble on the whole compared to the German example.

(*Dr Evans*) I think you are absolutely right in saying that there is a permanent problem for the funders of the science and technology infrastructure of the UK, which is primarily the government although not exclusively because there are other important players like the medical charities which are putting enormous sums of money into the science base at the moment. There is a permanent problem in the balance between developing knowledge and understanding of science, which is the bedrock on which everything stands, and then the need to apply this to particular problems, whether these problems are problems associated with wealth creation, which is what the DTI generally concerns itself with, or other problems to do with the quality of life perhaps in the health area or the environment area. The White Paper "Realising our Potential" tried to set out what our balance between those two should be in saying that we must go for the twin goals of excellence and relevance. We should not simply fall into the trap of saying it is either/or. I happen to be a member of two research councils, the Engineering and Physical Sciences Research Council and also the Particle Physics and Astronomy Research Council. PPARC in many ways does not have this problem so acutely because its mission is basic science but even PPARC (and I very much applauded this) has recognised that it plays an important role in our society in attracting young people into science through the accessibility of the science that it does. My own doctorate is in astronomy, I was trained as an astronomer and I know from my experience, and that of my own children as well, that it is a very good way of getting young people involved in science and many distinguished scientists and many people who carry on and do science were brought in by the attractiveness of that science. PPARC has consciously targeted the public understanding of science, as well as the excellence of its own science which is very important and must of course be paramount as part of its mission. The Engineering and Physical Sciences Research Council also spans, in a much clearer way, the need to sustain the bedrock and to sustain the application. One of the things that I think we have discussed around the table quite a lot in the last couple of years is the balance between directed mode activity and so-called responsive mode where all we are doing is saying we have a pot of money and we want the academic community to tell us what the priorities are. And I think rather contrary to the view that is sometimes expressed in the academic community, the Council has been very keen to sustain that responsive mode as a dominant mode for funding of science. The current situation in EPSRC, it is slightly complicated to explain, is that we think about 60 per cent of our funding is responsive or what we call "conditional responsive" where we are not setting out in detail what needs to be done but we are saying, for example, there is a priority to be attached to clean technology but we are not saying what clean technology. From my own experience of being involved with the research council, my own personal judgement is that we have a fair balance in the situation at the moment between the need to sustain this basic excellence and to ensure that science and technology is being pursued in ways which will lead to satisfactory exploitation, whether this exploitation is in wealth creation or in the quality of life. Having said that, it is not something we can afford to relax on. It is a permanent issue for people associated with science and technology policies.

11. I have spent a fair amount of my life funding research councils and one of the worries I have had is it is very difficult to get industry involved in not the basic science but the techniques that are used. If you go to DESY or CERN or Rutherford Appleton or the ISIS laboratory you will there see extremely advanced technology. I managed to get the Foundation for Science and Technology to go to ISIS recently and their eyes were opened. I do not think there is enough follow up of that kind. Would you agree?

(*Dr Evans*) I think that view is one that has been shared by PPARC and for that reason PPARC has created a funding mechanism, surprisingly for a research council whose primary responsibility is particle physics and astronomy, to support collaborative proposals from industry and the academic departments relevant to its size to develop new technology (the PPARC Industrial Programme Support Scheme) and it is my perception that that seems to be working very effectively. For example, the kind of science and technology which you need to make these massive particle physics detectors for CERN or for making x-ray observation may well have applications in advanced medical imaging. That kind of thing is beginning to come out as an intermediary output, a halfway house output in the work of the research council. I entirely agree with you, it is wrong to say the problem is all on the side of the research councils. We have to get industry to recognise that this is an attractive and worthwhile and important new technology which is wealth

Lord Dainton *contd.*]

creating and on which there are market opportunities and then we come back to some of the other territory I have been talking about, home territory for the DTI, of how can we lift the eyes of the great mass of industry to see what potential riches lie before it, if it can only be tempted into investment and participation with the science base.

12. My son runs a large group at DESY. He tells me, I have not myself visited it, that it is very difficult. I tried to get an arrangement for industrialists to go there because there is a great deal of engineering there and you will find nuclear physicists managing enterprises which are technological for which they were not trained but of course they learn a lot and quite quickly. He said that you get much more interest from German industry and since it is now serving all the former eastern territories from there, countries like Poland. Is there anything the DTI can do to broaden the interests of industrialists and make them more aware, but not just leave it at that because being aware is a good feeling, you have a jolly, but nothing happens. Is there a mechanism for making better use?

(*Dr Evans*) There are the traditional mechanisms of setting up rules for public procurement which are intended to frustrate the natural tendencies of governments to spend their own money on their own firms. I know from my own experience of operating them that you have to take them seriously. The reality is that Germany is blessed with an extremely strong cadre of highly sophisticated predominantly medium-sized mechanical and electrical engineering companies who are extremely well placed to come in and take that kind of business. It would only be fair to say that the United Kingdom simply does not have that strength and depth so it is an uphill struggle for the United Kingdom. But we have tried in relation to CERN to identify the technological opportunities and we have somebody at the Rutherford Appleton laboratory who is co-funded by the DTI to try to draw attention to these really exciting technological opportunities and important new technologies that would have an application elsewhere than just in the particle physics detectors to try to get greater participation in CERN and we have had some success with CERN. Part of the difficulty is that CERN being where it is in Geneva is physically nearer France and Germany. We are very happy to give you a note on that if you would be interested.

(*Dr Keddie*) Although it is not something we can formally do we can help to bring about peer group pressure on companies just through example because there is a tradition in the United Kingdom that companies do not tend to look outside themselves for new ideas and so on. That is beginning to change, certainly in some of the leading edge companies, and they are the best people in fact to persuade others either through supply chains or in other ways to do similar. I agree entirely with your point about industrial tourism. That isn't going to do anything for the company but if the technical side of the company can become more part of the strategic business side of the company then ideas do begin to work.

13. There is a difficulty here that many of the people one wants to help (a) tend to be unaware of their deficiencies and (b) lack the confidence to make that little step to go a bit further. Does the DTI do anything to bridge that gap, which in my experience is a difficult one?

(*Dr Evans*) I think it goes to the heart of our policies in improving the contact between the science base and companies which really, if you want to sum up what we are trying to do in one sentence, is what we are trying to do in my part of the DTI. In general, because we have such an excellent science base in the United Kingdom, it is reasonable to expect that an academic in any given field who is active in research will know the world network and will be participating in the world network in his particular subject so the academic will have the confidence and understanding to know what is new and what is coming forward in that area. What we have got to do is make sure that is communicated in a productive and practical way into companies. The issue of technology transfer is like impedance matching in electronics. Not only have you got to transmit the message along from the science base but in a form that is capable of being received by the company. You have to match the two sides up.

14. Does the concept of the Technopole help in this?

(*Dr Evans*) Do you mean science parks?

15. Nodes around the country.

(*Dr Evans*) Yes. Sustaining excellence, promoting collaboration between different parts of the science base has become an increasingly important factor in our work on biotechnology and our work on the information society where we think that the United Kingdom is very strong in the biological sciences. There is no question in the biological sciences of Germany being better than we are. Germany and indeed France envy the strength of our academic science base, the strength of our companies which have been able to show success, even success on the stock market in terms of their evaluations, the new growth companies that have come forward in the last few years. Even with this strength we often have university departments which understand only part of the action, who know about a particular part of the science or the application which, if they were put together with two or three other competent scientific departments, could produce a coherent and broader platform for technical exploitation in the United Kingdom. We have introduced a new programme in the last six months to promote the development of technological platforms for biotechnology between different academic departments with complementary expertise so that they can then do a bigger job and create a better basis for exploitation in the United Kingdom in the future. Roughly the same kind of idea underlies many of our activities in the information society where we are trying to create virtual networks between different academics. Academics are tremendously good at using the information society. They got the network first of all and the software for the World Wide Web was created in CERN. This information society is home territory to the academics. The academics are actually very good at forming the bridgehead leading the more commercial parts of the economy into these areas and promoting the constructive aggregation

Lord Dainton *contd.*]

and the positive nodes of growth is something we are working hard to learn how to do. I do not know that we really know how to do that. We are making forays to see where we can make it work better.

Lord Cuckney

16. Are there any industries or sectors of industry that are clearly laggards that you are targeting? In the new initiatives and programmes are you targeting any particular industries?

(*Dr Evans*) The Technology Foresight programme identified some broad strategic priorities which I think often do not relate to single industries or at least not uniquely to single industries. I was thinking that one of the priorities under the Technology Foresight programme is sensor technology. In one sense there is a sensor technology in that we do have people who make sensors and know how to operate them in instrumentation. We have a strong instrumentation industry in the United Kingdom but in another sense sensors go into something else and it is into the something else that you apply. In terms of promoting particular industries, over the summer we have done quite a large exercise to try to simplify the kind of business support that we have on offer from DTI and from other government departments partly because we found small firms were very confused about what was on offer and the conclusion of that was that we should be operating in a much more "open challenge" mode, that we should be asking different sectors to bring their own problems to us rather than ourselves determining particular actions or particular programmes and we are still in the middle of running the first round of a competition which we have called the Sector Challenge. We have invited bids from trade associations, research and technology organisations or other groupings of companies across the country, across an open range of all the sectors. We received 601 bids in the middle of November and we are literally at the moment trying to separate those out into a top half whom we will encourage to go on and make full bids, and a bottom half, so to speak. So our policy has moved more in the direction of trying to be open to solve the particular needs of particular sectors, as seen by the sectors themselves, rather than saying that sector A is more important than sector B and therefore should deserve more of our money for that kind of industrial support. We still stick by the priorities for basic technology which were set out in the Technology Foresight reports which in some rather loose way might be said to map on sectors.

Chairman

17. If we were to talk other people's money for a moment, how has the Technology Foresight initiative influenced, if at all, the creation or development of funds for particular sectors and activities? What kind of gearing have you had out of the initiative in those terms?

(*Dr Evans*) In terms of the response from the City in venture capital funds?

18. Has the Technology Foresight initiative had any impact?

(*Dr Keddie*) I think it is too early to say whether it has had an impact in any significant measurable way in terms of flow of funds. What it certainly has done is engaged the interest of a growing number of financial institutions both in terms of what is Technology Foresight, or Foresight as we should call it these days, in terms of technology and markets and drawing the attention of institutions and investment companies to the priority areas for the future and there is certainly a growing interaction as well between some of the financial institutions and the academic community. For example, there is a growing recognition that risk management in the United Kingdom is not particularly well understood or applied and that has been a direct result of Foresight. Has that generated several billion pounds worth of technology in firms? We cannot say that at the present time. Is it likely to influence that? I think with confidence we can say yes because the nature of the dialogue between, certainly the better managed companies and better financial institutions is improving and the quality undoubtedly is getting better and Foresight is playing a part in that.

Lord Winston

19. Given the role of research councils that you talked about in the universities, do you think the presence of the OST within the DTI has improved innovation?

(*Dr Evans*) My perception from within DTI is that it has enabled us to discuss, much more productively than was the case before, the way the OST initiatives can work positively to develop the kind of objectives we have talked about this morning than was the case when it was another department. Simply the fact we are part of the same department has meant in the natural process of developing our ideas we talk to each other more than we did before. My overall judgement is that it is a distinctly positive development and that it promises well, so to speak, for the output of innovation. The output of innovation, as I said at the outset, is extraordinarily difficult to measure.

20. Have you been able to apply measures and comparators to this problem?

(*Dr Evans*) I do not think it would be reasonable of me to expect that we could track an organisational change like that through to developments in the economy. What we might be able to do is look at the way that new proposals have come forward. It is certainly true that in the kinds of work we have done in trying to implement Foresight and the development of our new ideas, including the new stage of Foresight announced by Mr Taylor yesterday, the development of those ideas was helped by the fact we were one department.

(*Dr Keddie*) The promotion of public understanding of science again is essentially a joint activity and therefore, if you like, in administrative input terms is hopefully being much more effectively carried out. We have merged our interest in finance for technology-based firms and that has been quite effective. As Dr Evans says, only time will tell what impact that will have on the economy itself which is what it is all about.

Lord Winston *contd.*]

21. Do you see the impact on the public understanding of science optimistically? Is it going well?

(*Dr Keddie*) It is making a difference. Is it making a difference with the speed and scale we would like to see, I guess no is the answer to that. We are talking about bringing around cultural change to some extent which is a 20 to 25 year exercise. It goes back to primary schools and education so it is a long haul. Equally we should not assume we can sit back and not be measured for 20 years either.

(*Mr Barber*) We have just started a review of the effectiveness of what is being done in the public understanding of science so far. We do not have results yet. We hope to report sometime next year.

(*Dr Evans*) An interesting micro example is we knew OST had some activities with the research councils. The industrial side of DTI has the expertise in the evaluation of programmes. It was a request from the OST: "Can we use your expertise in evaluating programmes to look at the joint activities which led to this evaluation?"

Lord Dainton

22. Your reply to Lord Winston a moment ago suggested that the DTI was getting something from the OST being within the Department of Trade and Industry.

(*Dr Keddie*) That is true.

23. Surely that is the wrong way round? My understanding of the OST was that its function was, amongst other things, to look at the role of science across all departments. There is a question here as to whether or not the relationship is the right one.

(*Dr Evans*) There are two main administrative units within the Office of Science and Technology. The bit of the Office which reports directly to Sir Robert May has as its main function the trans-departmental co-ordination of science and technology and, for example, it also looks after the LINK programmes. For example, in the LINK programmes, at least half of the programmes have been funded by DTI, so it actually does help to have them in that kind of co-ordination, I think. The other part of the Office of Science and Technology under Sir John Cadogan deals with the research councils and again there is very strong collaboration between the research councils and other parts of the DTI which has been assisted by the office being in the Department.

24. Assisted by the geographical move? That really is a surprising statement and one raises the question as to whether it is desirable too.

(*Dr Evans*) It may raise the question, but I am giving you my perception from the point of view of being within the DTI.

25. I can see that from your point of view.

(*Dr Evans*) It seems to me that it is a positive thing that senior members of the Office of Science and Technology participate in the corporate discussions within DTI because I think it is extremely important that science and technology issues and perspectives from science and technology should be one of the inputs to our decision-making process.

Lord Winston

26. Do you think that the Department for Education loses out as a consequence?

(*Dr Evans*) Well, it is a long time since the Office of Science and Technology was in the Department for Education.

27. I just use that as an example.

(*Dr Evans*) The Department for Education is now the Department for Education and Employment.

28. Sure.

(*Dr Evans*) I do not know enough about the consequences for DfEE to be able to comment on it.

Lord Dainton

29. There is just one thing which is that you have glossed over the fact that it was the Department for Education and Science and that that change is a fundamental one because it has made a separation in everybody's minds between the higher education sector and the science sector and this has effects which are quite important of a psychological no less than a real kind.

(*Dr Keddie*) These are pretty fundamental questions, I think.

30. Yes, indeed.

(*Dr Keddie*) I think that we need to be clear as to desirable on behalf of whom. I think that if we are thinking in terms of what we are trying to do in the economy as a whole, certainly the signs I have seen of the changes of late I would think are to the benefit of the economy as a whole and I think they are working together more effectively and I think that is an important outcome. I appreciate exactly the point you are making, Lord Dainton, as well, that it then gives a different perspective in terms of higher education and where it sits in government thinking and so on, but it is the ultimate impact on the marketplace out there I guess which we should judge the changes by in the long term.

Lord Kirkwood

31. I just wanted to ask a further question about the Technology Foresight Programme, or the Foresight Programme as we have learned to call it. Because of the nature of its approach, which was a sector approach, there are necessarily gaps in the areas that it has studied in innovation and it has been suggested that nanotechnology is one of the gaps which was overlooked. Is there a strategy within the DTI for meeting this problem regarding the gaps?

(*Dr Evans*) I think it is inherent in doing any exercise like Technology Foresight that the approach has to be carved up in some sort of way in order to make it manageable and that the decision you make about creating whatever it was, the 15 panels, inevitably makes some problems more difficult to deal with than others and an example of that was the marine area where the marine interests felt that they had not had sufficient attention paid to them and, subsequently, OST created a marine panel to look further at the issue. But I think in relation to this particular area of nanotechnology, it is important to

Lord Kirkwood *contd.*]

remember that DTI is not only acting in this area of Foresight. We have conducted very extensive competitiveness analyses of particular sectors, industrial sectors, and we use those in shaping our work and we continue to support LINK programmes which may or may not coincide exactly with one of the areas identified in Foresight because the aim in developing LINK programmes is to develop a coherent body of work rather than simply respond to three lines in the report. There was a LINK programme in nanotechnology which I think is closed to new proposals. I do not believe it has been evaluated.

(*Mr Barber*) It has.

(*Dr Evans*) It has?

(*Mr Barber*) Yes.

(*Dr Evans*) Well, you might want to make some comments about the evaluation of it.

Chairman

32. I am sure it was only last night!

(*Dr Evans*) I think it is fair to say that we cannot carry on for ever having the same LINK programmes. Having spent three years trying to build connections in a particular area, I think we then have to move on to new areas.

(*Mr Barber*) What the evaluation found was that there was a considerable expectation of commercial promise, but it was five to ten years off and the companies which had participated were continuing to work in the area. Nanotechnology promises a good deal, but it is rather early in its stages of development, but I think there are people working away in most of the areas covered by or advanced technology collaborative programmes. Once you have established the link between universities and companies, where these links prove to be well-founded they tend to go on. If we can get them going, we can often withdraw and leave them to go on without government support. They may not have quite the same profile as if they are being talked about in Foresight, but things are probably happening.

Lord Kirkwood

33. The danger is literally that the Foresight Programme does tend to give a sort of ossified structure in the end which may make it more difficult in fact to make proposals which are outside that rather rigid scheme.

(*Dr Evans*) The aim of the Foresight Programme was to help set some priorities, to help government in its job of funding public research and prioritise what it did and it is in the nature of that statement that there are some winners and some losers, but I think it is a very right comment to say that you cannot do that once and then say you have done the job and then you do not need to do something else and certainly all other Foresight activities, Japanese and German and all the other ones, have repeated the exercise periodically. The same is true in the UK and it is our intention to go forward and do another exercise broadly of the same nature, but hopefully improved in learning any lessons we have learned from the last time, in 1999 so we are roughly five years on from when we started and we are going to do the same sort of thing. I think it would be surprising if the priorities identified were all turned on their heads in the passage of five years because I think that the characteristic timescales of the things we are talking about are quite considerably longer than that, but I think at the margin and in particular areas there is every chance that the priorities will emerge differently having looked again and that is the purpose of doing it again.

Lord Cuckney

34. I wanted to ask you your views on the role of "business angels" which we have heard about and whether you think that sort of pre-venture capital funding has an application here and how can one encourage it?

(*Dr Evans*) That certainly is quite a high priority, but I might ask my colleague to deal specifically with that.

(*Dr Keddie*) Yes, we would regard business angels as a very important part of providing the early-stage finance, particularly at the seedcorn stage. Not only do they actually provide the finance, but they also bring business and marketing skills as well and that is probably of as much value, if not more value, as the money in a perverse sort of way. They have been there, they have done it, they understand what the difficulties are and so on and there have been both a number of private and DTI-supported initiatives to help build up business angel networks within the UK over the last three to four years with some success. I understand the British Venture Capital Association, in looking at the situation last year, 1995-96, concluded that there was something like £25 million raised for something like 200 businesses through business angels, or something of that order. Now, that is not massive in one sense, but when you think of the scale of finance required at the bottom end, it is reasonably significant, so it is moving in the right direction. Also other fiscal changes have been made through the investment side, the Enterprise Investment Scheme, and also recent changes in the Budget should also in fact help encourage more business angels to participate. So it is nothing like on the scale in the United States, but it is clearly very important. The United States is a different culture economy, it is a more entrepreneurial economy and larger scale, but there are signs that we are moving in the right direction in the UK. Is it moving again fast enough and in a big enough way? No. Is it moving in the right direction? Yes.

35. How specifically are you encouraging it?

(*Dr Keddie*) It depends what you mean. If you mean are we encouraging business angels to target specific types of business or specific areas of technology, no. It is more in fact helping business angels themselves or potential business angels understand that there are opportunities, investment opportunities out there and helping with information for them and with as simple things as putting business angels in touch with each other or potential business angels in touch with business angels who

Lord Cuckney *contd.*]

have already done it in the UK. It is partly a confidence-building exercise.

36. Do you keep a register of them?

(*Dr Keddie*) Not centrally within DTI or at least I am not aware of our keeping a register of them.

(*Dr Evans*) No, I do not believe we do. The business angels seem to me, as I said at the outset, to be an extremely important part of our business infrastructure and one which, as I said, is getting a bit better in the UK from where it was, but it plainly sits rather more clearly on the sort of market side than on the public sector side because what we are trying to do is get people to put their own money in and it is not taxpayers' money that we are talking about, but it is their own money which they will be investing. We have certainly talked quite a lot with banks and the National Westminster Bank has put a lot of effort into trying to improve its relationships with high-tech companies and indeed I think they have a very interesting and worthwhile story to tell. They, for proper commercial reasons, have been trying to set up their own networks of business angels, of people who can assist in this kind of thing to assist in the process because you do not want to develop a company solely with debt, but you want equity as well. I think also some more informal networks are coming into play with the Business Links, as part of the Business Link activity, and it seems to me that probably, in my judgment I have to say, not knowing an awful lot about it, a more local, more disaggregated network might be a better way into this problem than trying to create some massive central register organised by someone in the DTI.

(*Dr Keddie*) There are other things which are happening in the marketplace which should help this as well. The Alternative Investment Market is allowing smaller firms to become listed or at least raise equity and if that continues to be the success that it appears to be just now, it will actually improve liquidity at the lower end of the marketplace because the business angels who are making their own investment can then actually finally see an exit for themselves and can reinvest. There is also now the European initiative, called EASDAQ, and I cannot remember what the initials stand for, but it is the equivalent of the American NASDAQ, primarily directed towards technology-based businesses in Europe and again that is very much a market solution, provided the different regulatory framework across Member States does not get in the way, so there are things happening that are all building a bit more momentum in this area than was the case five years ago, I would say.

Chairman

37. A most interesting piece of evidence put to this Committee on the growth of the phenomenon in the United States identified as one of the important contributory causes, if you like, the clustering phenomenon, that you had a marriage between technology transfer and life as a business angel in particular narrow sectors or sub-sectors of an industry, notably of course in California. Now, is this a picture that you recognise and, if so, how could we encourage such a phenomenon in the United Kingdom because that does seem to fall directly within your responsibility in relation to general enterprise encouragement?

(*Dr Evans*) It is a picture I recognise and it is clustering both in technology and geography because there is a sort of clustering about IT and clustering about the biotechnology companies. One area where something similar has begun to happen is in relation to the innovation parks, the science parks in universities, where the "mentoring" capability in some of the science parks has included, when and where it might be appropriate, the introduction to the relevant type of business angel in the UK and the creation of a network around the particular science and particular incubator centre. Apart from generally welcoming this as a phenomenon and indeed supporting the idea of incubating units, and indeed we are doing something to promote mentoring in the biotechnology area, we have gone out to tender to seek a mentoring service for academics or for others who wish to set up and we are thinking maybe of helping to set up companies in the biotechnology area in order to ease them through that initial stage. What we have not done though is looked hard at this issue, at least as far as I am aware, of whether we should be positively encouraging the networks of business angels with taxpayers' money. I think that is an area which we have not simply done anything in.

(*Dr Keddie*) One of the very interesting things which happened in the UK very recently is Merlin Ventures which is being headed up by Chris Evans who is a well-known entrepreneur and very successful in the biotechnology field. He has succeeded in getting a lot of financial institution support for an investment fund, but the part he is playing is actually helping to put together people with the ideas and bringing different technologies together rather than just looking at a single technology, so there is a better overall technological package, and then bringing in people with the marketing and commercial skills as well and that may take six or nine months' investment of time, real quality time in terms of putting that team together and then bringing in the financial institutions at a slightly later stage so it raises the whole probability of success. That is again very much a private sector initiative, but I guess it has been encouraged just simply because of the changes in the economy over the last two years and in some of the changes in the fiscal system as well. We ourselves are going to be talking to the British Venture Capital Association to see if there are ways we can work with them, not in terms of putting in public sector money, but in terms of building up networks of expertise which can help, if you like, the near misses to improve their prospects of getting money.

Lord Dainton

38. Can I ask whether BTG, the British Technology Group, has been of any value in this context?

(*Dr Evans*) BTG is an outstanding success. One of the points of evidence that we point to in demonstrating the fact that the innovation climate is,

Lord Dainton *contd.*]

so to speak, on an upward trend is the success of the flotation of BTG when they raised more money, the success of the flotation of AEA Technologies and the success of the flotation of CRL from Thorn, so I think there is a much more positive attitude in the financial institutions as demonstrated by the hard money that came forward. BTG does have a role in this, although there are numerous other investment trusts and obviously 3i itself is very interested in this kind of area and has been interested in promoting high-tech start-ups.

39. I asked the question simply because BTG did establish its credibility over a long period of years from its predecessor NRDC which was not so good until it was paid for and BTG has, I think, developed a kind of unique way of operation which is understood by the universities.

(*Dr Evans*) Yes.

40. Could that be improved in relation to other firms? You mentioned Chris Evans, for example, but has he got that same kind of network, because he needs it, does he not?

(*Dr Keddie*) I would say that Chris Evans' network is different, but probably just as effective. The fact it is different I do not think matters. He has just got a different set of contacts, different people he knows and so on.

41. Within the universities or elsewhere?

(*Dr Keddie*) Both within the universities and within companies and financial institutions. The strength of Chris Evans is that it is his university credentials, his business credentials and his contacts actually and he brings all those three elements together.

Chairman

42. Seen from your perspective, does financing need to be improved for technology-based small firms during the crucial start-up period?

(*Dr Evans*) The short answer is yes obviously because the start-up phase is an extremely important phase, but there is a ladder of growth which any company goes through, particularly a high-tech company which has got the capability of growing rapidly to a large size, and there is a wide range of government instruments to assist in that, starting with the small firms loan guarantee which is a system which provides a guaranteed loan and it is operated by the banks and up to, I think it is, £100,000 or £120,000 or something like that and a number of small, successful companies I have talked to have said that that was extremely important in getting them going for the first six months or for the first twelve months in that it created the core out of which the business could be created. At a later stage we have our SMART and SPUR awards which are also cited by successful companies as being very helpful in providing their grants which are usually again on the scale of roughly £100,000 or potentially a bit bigger in some particular circumstances and they in practice are an effective way of taking companies forward. The really hard point though is that not every idea is actually a good idea. Not every good idea is actually going to pay off in the marketplace, so there is a complicated decision rule about this and determining what is good and what is not bad is a very subtle and complicated business and I certainly would not say that it is appropriate for taxpayers' money to be the basis on which all these decisions are made. I think it is necessary for there to be a rather complicated interaction between private sector enterprise and culture, venture capital trusts and all these kind of things and the public sector infrastructure which is often the source of the innovation in the science and technology area.

(*Dr Keddie*) It is not a shortage of money, as such, in the United Kingdom, there is plenty of money, but it is actually getting access to that money on the right terms and I think the real value of the sort of work the Bank of England has done, some of what we have done and the Enterprise Panel has done in looking at incubators is that the issues surrounding financing small-growth businesses, particularly technology small-growth businesses, are now much better understood by everyone and if they are better understood, then that should actually help to raise confidence and encourage those people prepared to invest.

Lord Cuckney] May I just say how important I thought Dr Keddie's point was about the development of the Alternative Investment Market and EASDAQ. I think exiting within a reasonable period of time is a major requirement and this is a great step forward.

43. I was asking you about not only, as it were, the use of government money, but how well the private sector was operating and whether there was a market failure at the second stage.

(*Mr Barber*) The financing of small, high-technology companies is a problem in every country and I am not sure, but there are many countries where the problem is probably worse than it is here, but I think everybody has scope for improvement. There are a lot of market failures and lots of people with good ideas, perhaps not many of them with a very good business background, and people with money to invest who do not always understand the propositions that are being put forward. They are often very small companies and they have no track record. This is where the need to overcome these barriers by a variety of means and institutions is a problem that all advanced industrial countries face. I think we have got room for improvement, but then so has everybody else.

44. Earlier on, Dr Evans, we hassled you on the comparisons particularly on the infrastructure in Germany and here. Could we perhaps take that up before it is lost?

(*Dr Evans*) I think in particular this issue of the readiness to invest, although the infrastructures are different, in particular the roles of the banks are different in Germany and indeed they fill some of the gap, I think my German and French colleagues would feel that the infrastructure we have in the UK is more positive and copes with many of these problems better than the situation in France and Germany. That is one of the reasons why the French and German Governments and the European Commission have been pushing so hard for this European market, this EASDAQ market, as Lord Cuckney said, because venture capitalists need the

Chairman *contd.*]

exit. Once the thing has got to a success and it is worth £10 million or so and it has some accounts which can demonstrate that it is actually making profits or it is going to make profits, then the venture capitalist wants to take out a slice of his money and that exit, and the availability in the market in which that exit can be achieved, is crucial. The relatively poor state of the stock markets for such small, unestablished companies in both France and Germany, I think, stands against them in this area, so I think we have the strength of the Alternative Investment Market, the AIM, in the UK with both its size and depth of liquidity which is actually a very positive feature for the UK. In fact the other comment I was going to make was about another aspect of technology infrastructure and that is that I think in both France and Germany more of the basic science and technology base is in public sector laboratories than is the case in the UK, so they are less university-oriented in the basic science base and you are more likely to find people from public laboratories than from universities and that is because the culture issues about public sector laboratories are in many ways worse and more difficult than the culture issues about universities. Universities in effect trade in a more obvious way, not necessarily as obvious as a company, but in a more obvious way than a public sector or a government laboratory does. The degree of entrepreneurial spirit found in the average academic would, in my estimation, be significantly higher than the degree of entrepreneurial spirit found in the average employee of a government laboratory and I think those are features which I think the French and German Governments would see about their own infrastructure. In particular, Germany has 14 large science laboratories, large research institutions and many of them had their origins in the nuclear power programme in Germany, but they have been working hard on trying to get them to play a more positive role in the economy at large and interacting more with companies and they have found that a really uphill struggle. It is really hard to get the culture of a nuclear laboratory which is still playing a positive role in the national nuclear power programme to turn its mind to working with small companies. I think that the length of time it took the AEA, the Atomic Energy Authority, to get to the stage where it was floated earlier this year is a measure of how long ago it started in about 1970, yes, probably 1970 or 1980 anyway, trying to do that kind of thing. I think some of those infrastructure problems are felt by my colleagues in France and Germany to be quite difficult for them. Now, in Germany you do have the strength of the Fraunhofer Institutes and these intermediary institutions do seem to work very well between companies, but they are terribly expensive. They still require subsidies of 50 per cent or more from the taxpayer and it is not entirely clear to me that that is an overall better infrastructure and a better way of organising the infrastructure than we have in the UK. The areas I am keen on trying to develop in our area is how can we use the strengths of our existing infrastructure and the strength of the funding from the research councils, which is already there, so to speak, more positively, rather than saying, "Well, we have got to invest anew" when we have got to create all of this with 50 per cent government money.

Lord Dainton

45. Are there any hard data for some of the opinions that are so freely expressed? I was thinking of the question of survival of a firm, when it gets to £10m. Are there any comparative data which indicate they go down the tubes more often as a fraction of those that have started in this country or another country from which we can learn?

(*Dr Evans*) I do not think that was the point I was trying to make.

46. No, it was not, it is a derivative point which was in my mind.

(*Mr Barber*) We did a study in the Department looking at bankruptcy several years ago but because of the different nature of bankruptcy laws in different countries, different insolvency laws, we found it extraordinarily difficult at that time to get meaningful comparisons. The answer to your question is no, there is no good comparative data.

(*Dr Evans*) I think the point I was trying to make was a different one, that the lack of a sufficiently dynamic venture capital infrastructure in France and Germany means that not enough companies get started and get up to that first stage, not that they go to the wall. There is not enough creation of new companies. I do not know whether or not we have information, again it is anecdotal, I do not know whether we could look but certainly I remember my French colleague telling me he was very proud of the fact that 30 new biotechnology companies had been found in France in the last three years. By comparison I thought that was two orders of magnitude below what I thought was happening in the United Kingdom. I have to say that is purely anecdotal.

47. Does survival of a company matter to you if it is replaced, in fact, by another one even in a different field, presumably economically it does not matter?

(*Dr Evans*) That is right, it is in the nature of small companies that many of them last for a relatively short time and then disappear. Then maybe the entrepreneur, as you say, moves on. That is another cultural point where in the States it is said it is a sort of battle honour to have survived a bankruptcy and it merely adds to your credibility the next time you want to raise money. In the United Kingdom you might be able to survive it, having gone bankrupt once you might be able to start again, but in France and Germany you will never ever borrow money off anyone again if you have ever gone bankrupt.

Chairman

48. Do you think the nature of our bankruptcy law is an issue here?

(*Dr Evans*) I am not in a position to comment.

49. Have you carried out any studies of the effect to which this may be an issue?

(*Dr Keddie*) It is an issue that crops up from time to time. I agree with David, certainly this morning I do not think we are in a position to comment on it.

Chairman *contd.*]

(*Dr Evans*) If you want us to comment substantively on whether the bankruptcy laws are well framed, we will have to take that away and seek better advice elsewhere in DTI.

50. If you could do that and also if we could have a copy of the study to which Mr Barber referred?

(*Mr Barber*) I know there was a consultative document published on the reform of the bankruptcy laws, that was several years ago. I am not too sure what has been published since but we will check that.

51. I was referring to the study you mentioned, which you said was inhibited to a certain extent by cultural differences in bankruptcy laws. We would still be interested in that.

(*Mr Barber*) We tried to find data and I think the idea was abandoned but we will check back what was done.

(*Dr Evans*) We will let you know the best that we have which is available.

52. If we dig behind these cultural factors, to which Dr Keddie referred earlier, and the comparison with the United States, usually you find there are structural factors shadowing these cultural differences. Are there any others you would wish to identify in comparing the enterprise climate in relation to innovation and exploitation in the United States?

(*Dr Keddie*) In structural terms I guess it is the sheer scale of the market, particularly if you are talking about small business, trying to introduce new technology into the market place and so on. Normally that is a niche market but if it is going to create volume it has to be international if the business is based in the United Kingdom. In the United States it would create volume in the United States to begin with. There is an issue around just the sheer scale of the market place they are going into. That changes the whole risk/reward ratio for investors as well.

53. There are some small businesses who make exactly the reverse point which is that the need to get to a certain volume to get anywhere is an inhibition on growth rather than the other way round. This is particularly true in the food industry endeavouring to get to the point to where it can sell to supermarkets. Is market size really such a determining characteristic of success?

(*Dr Keddie*) You can always find exceptions, I guess. I am generalising at the present time. The food industry, which you picked up, I cannot claim any particular knowledge of that, but it is certainly one of the points that keeps being made and raised. You will find that a lot of successful technology based businesses in the United Kingdom are operating overseas very quickly. If you are going to be taking evidence from Duncan Matthews, for example, of Nat West I think you will find—I should not speak for him—these are the sorts of issues I suspect he will raise as well when they are actually putting together financial packages for technology based businesses.

54. Is there a role for the DTI in this respect?

(*Mr Barber*) There is some role. The problem for high technology businesses is if, for example, you start off producing some high technology component you will very quickly get to the limit of that particular market so then you have to move to producing the whole product itself. That involves a quantum jump, not only in the volume of your sales but in the nature of what you do. Before you were selling to purchasing managers of large companies, now perhaps you are selling to end users, eg hospitals in a different kind of marketing function. You may also need different production facilities. The whole nature of the business changes and sometimes businesses find that they have these quantum leaps that they have to make. I think where we have helped in the past is we can help with advice on business processes for example, if they need to go and learn about marketing they can go into a Business Link. If they have to do R&D to scale up their product then they can apply for a SPUR grant. We do help them along the way but actually getting a company to grow from being very small to very large involves many transitions on the way. In business and technological terms many of these are difficult. Where in a sense the United States is different is that you can get a computer company like Sun systems, which went from nowhere to multi-national size in ten years, but it is very hard to see that happening in the United Kingdom. It would be selling in 20 countries. Sun basically made itself big in the US and thus had the muscle to push itself into world markets. When Acorn and Apricot in the early 1980s tried to break into the US market in order to enjoy the benefit of scale, they both came a cropper.

55. Does the single market programme not alter this balance of advantage?

(*Dr Keddie*) It will in about 20 years time!

(*Dr Evans*) I think certainly there is a role for the DTI in all of this and that is what we have been trying to do through the development of the Business Links because I think we recognise that the traditional functional splitting of DTI, into people who worried about exports, people who worried about technology, people who worried about other things, was not addressing the problems of a company in a whole way. We needed, therefore, to try to improve our connection by improving the way in which we could get assistance through to companies covering all these different factors, each one in the right proportion for that relevant company. That is why we are trying to deliver more support through Business Links through to the company more effectively. We will never reach the situation where we solve everybody's problems every time but that is not the way of the world.

(*Dr Keddie*) We have a role in understanding the market place and helping to pass that on.

Lord Dainton

56. On the question of survival of companies which often begin on a single idea and sometimes fail; even in the States High Voltage Engineering on Route 128 was a classic example. Are there difficulties in this country for a firm that starts on a technology and then fails to innovate with the kind of processes which it has? Is that a common method of failure as distinct from lack of finance to grow, do we know?

(*Mr Barber*) I do not think we have any hard evidence on that.

57. There is quite a lot of that.

Lord Dainton *contd.*]

(*Mr Barber*) What we know anecdotally is that you have one product companies and if they fail to innovate, that is it.

(*Dr Keddie*) I do not think this answers your question, my Lord Chairman, equally I guess this is semi-anecdotal evidence, but technology based businesses do tend to survive better than many other businesses in the United Kingdom.

58. Even the best businesses could have gone down, one thinks of Rolls Royce at one time at the end of the 1960s but that saved itself by continued investment. I often wonder where its money came from.

(*Dr Evans*) Yes, the Government, I think was one point. The point I was going to make was I think our SPUR programme has often been used by single product companies to develop the second product which then allows it to succeed and spread its risk; because the problem is the strategic risk for a single product company that somebody else comes in from nowhere and takes all the market. The SPUR programme has been an effective way in many cases of giving companies a second line which then allows them to continue. Obviously that is all to the good where it happens. The point you made before that not all small companies survive longer than five years, there is quite a high mortality rate, natural mortality rate, I think that is true in every country, of small companies.

(*Mr Barber*) The people in this country who know the most about survival of small firms are the ESRC Centre for Business Research in Cambridge. They have done surveys, they have done some longitudinal work surveying companies two or three times round. I think if you are interested you should talk to them.

59. I was struck by a statement which appeared in one of your papers that you were reducing the number of your activities, concentrating them, from 130 to something like 20. That leaves activities like SPUR untouched, does it?

(*Dr Evans*) Yes, that is what I referred to earlier, this exercise to simplify our support.

60. Thank you.

(*Dr Evans*) What we have in mind for SMART and SPUR is to bring the two schemes closer together, probably as one scheme to simplify their administration and to make them more user friendly, but in essence because we feel that they are very powerful and very helpful schemes we will carry on with them.

61. Did you shed the other 100 because they were too confusing?

(*Dr Evans*) The confusion was the reason. I have to say it is interesting that even civil servants in DTI did not know what the full 140 were partly because a lot were particular manifestations of general problems in a particular sector of industry, for example something which was targeted on the furniture industry, if you were not dealing with the furniture industry you would not know about that. What we have done is we are moving towards a system where we have a smaller number of headline schemes of which SMART will be one and the LINK programme will be another and the Teaching Company Scheme will continue, the major successful schemes on which we have a good track record. Then this more, so to speak, one-off activity will be funded not by DTI civil servants proposing or other Government department civil servants proposing a particular scheme but in response to the bids which come in from the intermediary organisations. It is a bit like moving towards a situation where we have more responsive mode grants in the investors' infrastructure. We do not want to say that we know the answer to what the problems are and how you solve the problems, competitiveness problems across the generality of industry, we want to say: "You, intermediary organisations, you RTOs or trade associations, you tell us what your best idea is, we will have a competition and we will fund the best ones."

Chairman

62. Dr Evans, may I end by thanking you very much indeed for coming at such short notice to talk to the Committee.

Memorandum by the Department of Trade and Industry

1. *Does our record on European patent applications reflect a decline or stagnation of innovation in the UK? [Recent figures on the number of patents filed per head of population puts the UK behind Germany, Sweden, The Netherlands, Denmark, France, Austria and Belgium in the EU]*

The UK's record on European patent applications does not suggest a decline or stagnation of innovation in the UK. Statistics from the European Patent Office (as well as from the UK Patent Office) show an upward trend in UK patent applications made, as well as in terms of patents actually granted, which would be consistent with increasing innovative activity in the UK.

However, patents are a far-from-perfect way of measuring the level of innovative activity in an economy. This is well established amongst experts in the field (from Gilfillan, Sanders and Kuznets in the 1960s, to Bosworth and Griliches today); some of the specific problems are:

- not all inventions are patented;
- different industries exhibit different propensities to patent—the UK does a considerable amount of R&D in aerospace where patents are filed relatively rarely;
- patents are not relevant to all firm sizes, sectors and areas of creativity;

— patents themselves vary enormously in their technical quality and commercial value;

— different countries' patent statistics are not fully comparable because of differences in national patent laws and administration—for example, German firms are understood to have a particularly high propensity to patent because of legal requirements.

Various methods are being developed which try to quantify these problems, but the Eurostat data ("Statistics in Focus" (R&D), March 1996), from which the figures in the question above appear to be quoted, has made no attempt to do so.

Nevertheless, it is noticeable that all seven of the countries with more patents filed per population also had higher per capita GDP than the UK, whilst the lowest ranked countries were the poorest ones. This indicates the extent to which patenting is a function of modern economic activity; the larger a country's economy, the greater the number of patents that its firms tend to file. In this sense, the UK might be considered to be doing well to be ahead of countries such as Italy and Luxembourg on patents filed per population. Indeed, in terms of the patents-to-GDP ratio, the UK was surpassed only by Germany, Sweden and the Netherlands in 1994.

2. *Many small firms with otherwise good product or process innovations fail to grow or fail completely in their first three years. What is the relative success rate of firms which have received support through the various innovation and technology transfer initiatives (eg LINK, Teaching Company Scheme, SMART, SPUR etc)?*

DTI continually evaluates the effectiveness of its innovation programmes to ensure they best meet the needs of firms. Results show that small firms who have taken part in DTI innovation programmes are generally more innovative, and that innovative firms exhibit better survivability and show higher rates of output growth, than non-innovators. The data also suggests that firms using DTI programmes have experienced faster growth than non-users.

Evidence relating to small and medium sized firms (SMEs) in general (rather than to those in the first three years of their existence) shows that SME involvement with DTI innovation programmes is positively related to new technology-based innovation. There is a statistically significant difference in the innovation rate between DTI programme participants and non-participants.

Some representative results from DTI surveys and evaluations show that:

— the innovation rate of those companies who participated in LINK was nearly twice that of those who didn't;

— the percentage of turnover on new products and process in companies participating in the Teaching Company Scheme (TCS) was about double that of non-participating companies;

— firms using TCS showed a better growth performance (of over double) than those who didn't use TCS;

— 20 per cent of mature projects funded by a SMART grant (mature being those which had achieved at least one year actual sales) were very successful (ie had a third year turnover of more than £0.5 million);

— 63 per cent of SMEs receiving a SPUR grant had established an on-going R&D capability as a result of the grant.

3. *The recent Bank of England Report on the financing of technology-based small firms said that SMART and SPUR schemes were too bureaucratic and time consuming, gave a too small window of opportunity for applications, and that the retrospective nature of the awards did not address the problem of current funding shortages. What is the DTI doing to address these problems?*

The President of the Board of Trade recently announced a simplification of DTI's support to business, as a result of which SMART, SPUR and also RIN (Regional Innovation grants) will be combined into one scheme (from April 1997) thereby reducing the complexity for SMEs applying for Government support. In the formation of the new combined scheme, DTI is working to reduce the burden of bureaucracy on applicants and will continue to do so in future to make the new scheme more responsive to market timescales where practicable and where it offers more value for money. However, the Department also has a responsibility to ensure public funds are only given to companies demonstrating sound financial management practices.

At present the SPUR scheme is open throughout the year as long as funds are available. The window of opportunity is therefore always there. Only the SMART scheme, which is run as an annual competition, has a timed call for proposals. SMART is over-subscribed by a factor of five, so there is clearly a demand for the support it offers. A competition, where each entry is judged to common criteria, one against the other, is the fairest way to allocate the limited budget for the scheme.

Experience has shown that the type of business which is most likely to suffer cash flow problems in the early stage of an innovative technology project is the very small or start-up business. The SMART scheme, which

is open only to very small and new businesses, provides an initial payment of one-third of the total grant at the very beginning of the project. It is not the case, therefore, that these awards are retrospective and do not address current funding shortages. The businesses which apply for SPUR, on the other hand, are generally well established and do not experience early-stage cash flow problems to the same degree. It is appropriate that they should claim grant against project expenditure in arrears, in order to ensure that the taxpayer gets value for money. Nevertheless both SMART and SPUR recipients are actively encouraged to claim grant against expenditure on a regular basis so that they should not incur debt or face cash shortages unnecessarily.

The Bank of England Report also states (recommendation 13) that "The SMART/SPUR scheme has been highly effective in leveraging in additional funds from the private sector at a relatively low public cost, and the continuation and further development of the scheme is desirable". Current thinking for the new combined scheme is that there should be a two-stage selection process, with short, simple "initial bids" used for pre-application sifting—thereby reducing the burden on unsuccessful applicants—followed by invitations to submit more detailed "full bids" for appraisal within a fixed timescale.

4. *What proportion of Business Links have Innovation and Technology Counsellors (ITCs) and what steps are being taken to improve the technological expertise of the Personal Business Advisers (PBAs)?*

There are currently some 60 Innovation and Technology Counsellor services established at Business Links and it is expected that the full network of around 70 will be substantially complete by early 1997.

Whether individual Personal Business Advisers (PBAs) need to improve their technological expertise will depend on their individual backgrounds, local demand from clients and working arrangements within the Business Link. For example, Business Links are increasingly managing their PBAs, ITCs and other specialist counsellors (whether for Design, Exports, Marketing, Finance or IT) as a single team in order to offer a comprehensive and effective service to clients. In such cases, therefore, it is more important that the team of advisers has a wide range of capabilities than that each PBA has a specific technological expertise. The establishment of the Information Society Initiative (ISI) and Local Support Centres, in conjunction with the Business Links, will further enhance the services offered by the team of Business Link advisers.

Ultimately, it must be for the Business Link itself to decide the balance of skills needed by individual PBAs in the light of the existing expertise of their total team and the needs of the local SME base. The Department fully accepts, however, the importance of ensuring that the ITCs and Design Counsellors are fully briefed on technological issues and would expect them to disseminate their knowledge as necessary to others in the Business Link advisory team.

8th January 1997

Supplementary note by the Department of Trade and Industry

Q12: *DTI's support, with PPARC, to encourage industrial applications' benefits to be accrued from UK participation in CERN, building on the work of the High Energy Research Facility—Industry Liaison Unit at the Rutherford Appleton Laboratory*

The current position is best summarised in the recent Government Response to the House of Commons S&T Select Committee enquiry into PPARC, published on 31 October 1996:

"The DTI and industry were the sole funders of the High Energy Research Facility—Industry Liaison Unit (HERF-ILU) based at Rutherford Appleton Laboratory, now part of the Central Laboratory of the Research Councils (CLRC). That funding was for a period of three years. Lengthy negotiations between DTI and CLRC staff about possible funding for future activities did not originally succeed in agreeing terms that met DTI requirements for matching funding from industry. However, the DTI has recently agreed to provide joint funding with PPARC, for an industrial co-ordinator to fill some of the gaps in the present coverage of the CLRC unit. The DTI has a very close involvement with PPARC on industrial liaison issues."

Q36: *register of business angels*

We confirm the answer, given in the transcript, that the DTI, itself holds no register of business angels centrally. However, there are a number of business angel introduction services operated by Business Links and by the private sector. These are listed in a directory produced by the British Venture Capital Association.

5 December 1996] *[Continued*

Q48: *smaller, innovative companies and the bankruptcy laws*

We have reflected on the points arising from giving evidence. Further examination reveals that DTI holds no internationally comparable data on bankruptcy laws and their effects on smaller firms' innovation behaviour. This is due to the inherently different regimes in other countries, in respect of what constitutes bankruptcy, and how it is treated. May we suggest the Committee could follow up their interest with the leading academic in this area: Dr Alan Hughes of the ESRC Centre for Business Research in Cambridge.

17 December 1996

THURSDAY 12 DECEMBER 1996

Present:

Cuckney, L.	Dixon-Smith, L
Currie of Marylebone, L.	Hogg, B. (Chairman)
Dainton, L.	Kirkwood, L.

Memorandum by Dr Elizabeth Garnsey, Cambridge University

TECHNOLOGICAL INNOVATION IN EMERGENT AND MAINSTREAM MARKETS

Innovation is conceived as the "exploitation of new ideas" in the Competitiveness White Paper.[1] It is often stressed that innovations need not be technological, yet innovations based on new technology have a role in the economy which is not self-evident. In this briefing paper we examine why technology-based enterprise is important in an innovative economy and review the problems of reaching mainstream users with innovations from emerging firms.

An economy which is innovating successfully has leading edge firms in emerging industries and markets; it also has companies diffusing innovation into mainstream markets. Among the most successful companies are those pioneers in emerging activity which also move innovations into the mainstream. In the UK there is considerable expertise and successful innovation in well established domestic industries such as food processing and especially mass retailing, in which profit margins are the highest in the world. There has also been healthy start-up activity of firms applying knowledge from the science base in new ways, licensing designs and providing mainly niche products, processes and services.

Where there has been less success has been in the transition from early niche markets to mainstream markets. Few UK technology-based ventures have grown into leading players on the industrial scene, with a few notable exceptions like Oxford Instruments, Psion, Logica and Domino Printing Sciences. Elsewhere, weakness lies in following up the innovations manifest in breakthrough technologies to reach mainstream customers with new products and services.

There are no simple answers to this problem. One cannot conclude from this failure that the start-up stage is not important; just as basic science is the seedbed of future innovation, so it is essential to have bio-diversity on the industrial start-up scene. Innovative ventures are needed which connect up knowledge from the science base with new opportunities in various industries by experimenting in a variety of technologies. Technologies do not emerge in isolation, they are continually feeding into and extending each other, as the clustering of related innovations in information and communications demonstrate. Start-up teams, including those whose firms subsequently fail, help to build the national expertise that is needed if it is to be possible to move ahead into new areas that are opening up. These are still on the horizon and beyond the view of the majority, including industry experts.

Greater business awareness is needed if entrepreneurs are to realise the full gains of their innovations. This is already in evidence from experienced entrepreneurs who engage in collaborative arrangements to reap the rewards of intellectual property by various means, including licensing strategies, for example. These are increasingly successful around Cambridge in companies like ARM and the new Acorn group.

But the more extensive wealth and job creating potential of innovation is realised not just by selling ideas but by embodying ideas in products and supporting services. This requires market-focused manufacture, both in-house and subcontracted. Here too technological expertise is essential, but it must be matched by a clear understanding of potential uses and users. Successful "breakthrough" firms with pioneering technologies are often successful because of their user focus, which starts with the customers who first commissioned the research. Technical solutions in search of problems are frequently on offer through technology transfer efforts, but this is rarely the way ahead; it is more effective to begin with a clear sense of pressing user problems which a new technology can solve.

Innovation is not a linear process that starts with science and ends up with goods in shop windows, as some earlier evidence may have suggested. It is a spiral process of continual interaction between technical and market opportunities. This is why it is not satisfactory to divide off pre-competitive from near market R&D and to provide support for the former but not the latter; the distinction is neither clear cut nor an adequate

[1]Department of Trade and Industry, *Competitiveness: Helping Business to Win*, Cm 2563 HMSO May 1994 p. 62.

basis for policy. Time to market is uncertain, the nature of the activity varies and small innovative firms cannot afford to do pre-competitive work.[2]

Having reached the early innovating customers, usually technical enthusiasts, the work of the innovating company intent on major growth has only just begun. And this is where leading edge UK companies often lose impetus. The failure to reap the gains of pioneering products has often been lamented, but there is insufficient recognition (eg in the Foresight Programme) of the great divide in outlook and requirements that separates the technology enthusiast and early innovator from the mainstream customer (figure one).[3]

The entire endeavour of developing and launching innovative products, processes and services must be user-focused.[4] The usual concept of marketing is too restricted to convey the kind of orientation required. Diffusing an innovation calls for identifying and selecting user groups, understanding how these differ as the market widens, getting very close to them to learn what they do and need and are prepared to pay. Above all it involves offering solutions to their problems, solutions that they recognise as useful and can afford. This is the kind of approach that Oxford Instruments has adopted, setting up new units with operating autonomy to develop new product lines and reach new markets. This kind of marketing effort is a costly process, and one of the reasons firms intent on growth which lack private means are likely to require external finance.

Figure One The Diffusion of Innovations

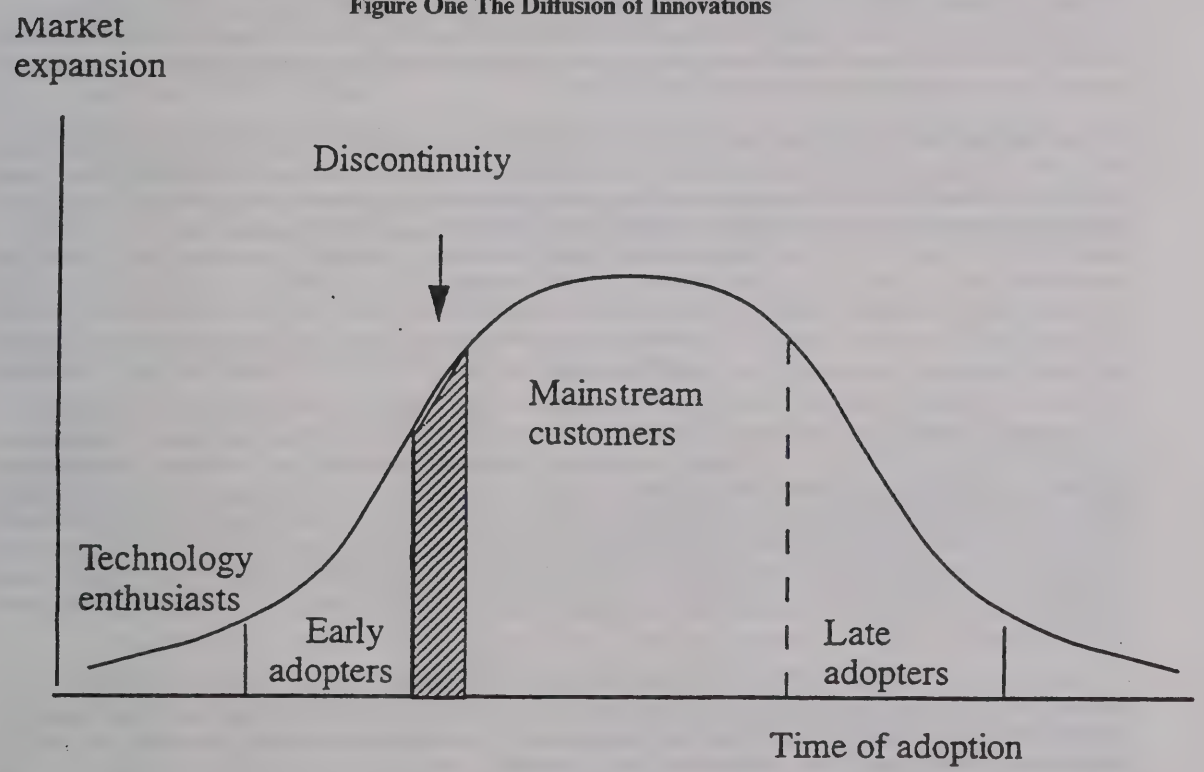

Figure One is based on work carried out in the 1960s and 1970s on the diffusion of innovations by Coleman, Rogers and others, and popularised recently by marketing consultancies. The discontinuity between early and later innovators is marked by hatched lines. Mainstream consumers, whether final consumers or big companies with a Not Invented Here syndrome, are ambivalent about innovation. They must be persuaded of the benefits accruing from new techniques, they look to endorsement from influential users, else they will not make the changes required to introduce and implement an innovation. To reach beyond the technology enthusiast, a company with an innovation to promote must be able to provide a user-friendly solution to a perceived problem or need among specified customers.

Not enough technology-based companies are seeking to reach potential users with their products. Consider the use of computers by teachers. Fifteen years after they were first introduced, most teachers are still not using computers in their day-to-day work because they do not realise the extent to which this could reduce their load. The IT teachers and a few enthusiasts use the computers and the rest of the staff toil away by hand

[2]Garnsey, E, Moore I, 1993, "Pre-competitive and Near-market Research and Development: Problems for Policy" *International Journal of Technology Management* 1993 Vol 8 No 5/6 69–83.

[3]The recent Foresight Initiative, though designed to identify future trends, does not identify the implications of this key problem. Office of Science and Technology, *Progress through Partnership* Report of the Steering Group, 1995.

[4]Davidow, WH, 1986, *Marketing High Technology; An Insider's View,* Free Press, NY.

as before. Yet in the universities most teachers are computer-literate. They need to be, in order to keep up with their research and their students, and the way was made easier for them when Apple Computers introduced their user-friendly Macintosh products into the academic market. Potential users will resist innovations unless they are delivered to them on their own terms. Computer companies are still providing "solutions" that take too much effort to master. The complications of using the information superhighway are reminiscent of driving in the age of the pot-hole and the hand-crank, when drivers had to be amateur mechanics in order to stay on the road.

There are huge opportunities for firms that deliver innovations to consumers in a usable form so that they can be assimilated without undue effort. This is why small innovative firms with breakthrough ideas are sought after as acquisition targets; others want to reap the rewards of turning their ideas into usable products or services that attract customers. Delivery of usable products to mainstream customers is the reason for the success of firms like Quintile International, the US clinical trials company founded, like many US high tech companies, by a British science graduate. This company diffuses R&D into mainstream pharmaceutical companies by organising and filtering clinical trials of products from new companies. In many areas, delivery of a usable product to the consumer requires collaborative arrangements because no one company can provide all the components required, as is clear from the interconnectedness of IT products.

Stress on competitiveness can divert attention from the importance of partnerships and alliances in securing the position of emerging companies. Innovators often succeed by keeping ahead of competition with unique products and services, not through local price wars of the kind that undermine the entire industry, as occurred for example in the British furniture industry.[5]

Firms become dominant in their industry by moving into the mainstream and diffusing innovations widely. But it is also necessary for firms to introduce a continual stream of new products and processes to keep ahead of the competition. In what follows, issues relating to high technology and new ventures are explored further, for the light they throw on ways to move ahead of the competition to reach new markets.

Applying Scientific Knowledge to Users' Problems

That there is scope for innovation in all industries is commonly known, but the significance of innovation in high technology activities is not always recognised, despite the efforts of the Foresight Programme to emphasise the relevance of science and technology to the economy.[6] The idea is often encountered that high tech and science based activities are elitist, outside the mainstream and in some real sense irrelevant to the bulk of business. Alternatively, the special merit of technology-based enterprise is not elaborated because taken as given, as in the report of the Bank of England on finance for technology-based business.[7] Thus it seems worth setting out why advanced technologies are a source of radical and incremental innovations with extensive relevance.

Technologies are problem-solving techniques embodying knowledge. By providing new solutions to old problems, or allowing new problems to be addressed, radical new technologies open up opportunities all around them. We can take as an example the development of the electron microscope. This was the product of knowledge from a variety of science labs in the 1930s and 1940s, brought to fruition 20 years later and now fully computerised. The resolving power of a light microscope is limited by the wavelength of light, the maximum possible resolution obtainable being equal to half the wavelength of light used. A beam of electrons can achieve a resolution 500 times or more better than a light microscope. Once commercialised and diffused around the laboratories of the world, this innovation, together with improvements in preparation of materials for examination, made possible many of the advances in biology that have occurred since the second world war, and hence the industrial opportunities to which these gave rise.

When scientific instruments firms that were making light microscopes found their markets becoming saturated, it was in some cases decided to develop an electron microscope. This requires a reconfiguration of suppliers, with a new role for electronics and computing suppliers by a loss of custom to more traditional firms. The new products impact on customers, leading them to make new purchases in order to gain a substantial cost and performance advantage, or enable them to do something new, as where for example the police extend their forensic methods. This impinges in turn on customers' other suppliers. Almost every firm in the production chain will alter its own input-output mix in response, reaching further markets. An innovation that started in the laboratory changes the way we work and live.

[5]Best, M, 1990, *The New Competition,* Harvard University Press.
[6]Office of Science and Technology, *Progress through Partnership,* Report of the Steering Group, 1996.
[7]Bank of England, 1996, *The Financing of Technology-Based Small Firms,* HMSO.

WHAT IS HIGH TECH ENTERPRISE

We can move from these examples to a broader view of how high tech enterprise makes use of scientific and technical knowledge. Sometimes the knowledge itself is new, as where findings about genetic coding were applied to protein synthesis for drug production. Or new applications of established scientific or mathematical principles may be found, as where geometry was used to reproduce classic typesetting designs for desktop publishing. Software or instrumentation developed for basic scientific research may be applied to practical problems, as where tracking instrumentation and software used in small particle physics was applied to cartography (by Laserscan, the first firm on the Cambridge Science Park).

High technology industry is essentially a dynamic category. We can distinguish between a spectrum of technologies on the basis of their assimilation in the economy.

(1) Technologies are "emergent" when knowledge is newly applied outside the laboratory, as when pasteurisation was first introduced into certain dairies in the 19th century.

(2) They become "diffusing technologies" as these applications are increasingly taken up in industry, the current status of micro–processing technologies.

(3) Once widely diffused they are "assimilated technologies" (eg, extruded and moulded plastics). Some technologies have remained standard over long periods until they approach the end of their industrial life, when they become "ageing technologies." (eg, the hot metal press).

(4) Ageing technologies are on their way out, but sometimes receive a new lease of life when applied in new ways or to new areas.

(5) Replaced by newly emerging products and processes, technologies become obsolete (eg, computer punch cards).

"High tech" is shorthand for emergent and newly diffusing technologies; over time the category refers to a different grouping of technologies as new knowledge emerges or established knowledge is applied in new ways and in new industries. Technology advances through new applications of knowledge to products and processes, changing the configuration of opportunities in the economy as the webs of production and consumption shift. In the past, steam and electrical technologies with their applications in transport, production and consumption had a similar massive impact on the rest of the economy until they were fully assimilated and then replaced by newer technologies and industries.

Currently three areas are of special importance: electronics, new materials and biotechnology. These will be extended by other key areas as environmental pressures grow and emerging economies alter current configurations.

(1) Electronics is still a key technology, as it has been since the 1960s. Though increasingly widely diffused, electronics continues to be renewed by newly emerging applications, e.g. currently in opto–electronics. There are especially important emergent and diffusing applications in telecommunications, computer hardware and software and specialist engineering. Micro–electronics is at the heart of the new information and communications revolution. It is now diffused throughout the instrumentation sector, making possible innovations in scientific and production instrumentation, including sensors and image processing devices.

(2) Biotechnology (including therapeutics, diagnostics, agro–technology) is the other key emergent area of our era. There are especially important emergent and diffusing applications in telecommunications, computer hardware and software and specialist engineering. Micro–electronics is at the heart of the new information revolution.

Two other areas where scientific knowledge is applied to new technologies are of increasing importance:

(3) New materials including ceramics, polymers and composites of generic importance in new and substitute products and processes.

Finally activities which are certain to become of increasing importance are concerned with:

(4) New and more sustainable forms of energy. This is an area in which public policy and regulation can stimulate innovation.

ROLE OF HIGH TECH ENTERPRISE IN EMERGENCE AND DIFFUSION OF TECHNOLOGY

The firms which pioneer these innovative technologies are especially important for their capacity to transform older industries, as these come to incorporate products and processes derived from the high tech sector. Their new ideas are assimilated by other companies through imitation, alliance and take–overs. Moreover it appears that major economic cycles are associated with the emergence and assimilation of key technologies. There is controversy over the timing and mechanisms relating technological cycles to "long waves" in the global economy (Kondratieff waves), but the various schools of thought agree that enterprise

plays a key role in initiating new and inter–related technological innovations and in diffusing these throughout the economy.[8]

The role of enterprising new companies in the initiation and diffusion of innovations results in part from the ambivalence of established companies towards emergent technologies. On the one hand there is recognition in the corporate sector that innovation may be essential for survival. Most established companies have specialist R&D units specifically to promote technological innovation. But on the other hand, large corporations are usually better at incremental innovation, modifications and refinements to their products and processes, than at radical innovation. Indeed radical new technologies may threaten to de-stabilise the markets that established companies currently control.[9] Factors that limit the extent to which leading companies are induced to innovate include the following:

1. Pressure to distribute dividends to shareholders to maintain current share prices rather than invest in R&D, the fruits of which are uncertain and some years off, where capital markets value dividends more than R&D record.[10]
2. The originators of the R&D and its innovative applications may fear they will be unable to appropriate the returns thereof.
3. Radical innovation can de-stabilise markets and erode the advantages of accumulated expertise and established firms with vested interests may have no interest in seeing this occur.

Many really novel technologies have been the work of outsiders who were not operating within the conventions shared by members of established organisations. It was not at Kodak that the photocopier was developed. Kodak was not an office-products company and the photocopier idea was not launched on the market until Xerox was established. But Xerox in its turn proved blind to the importance of an emerging technology; as at IBM, there was a failure to recognise the importance of the micro-computer. A user-friendly micro-computer with graphical interface and networking potential was pioneered within Xerox's own research laboratories in Palo Alto in 1973, but a product based on these ideas was only taken to market after Apple Computers was founded by "computer kids"—Steve Jobs and Steve Wozniack. Similarly, the biotechnology industry in the US was to a large extent the result of bio-scientists starting their own enterprise, rather than the fruit of the laboratories of big pharmaceutical companies. Although Schumpeter believed towards the end of his life that "invention factories" in well resourced large companies would become the main source of innovation under capitalism, the example of the biotech industry is much closer to his own earlier perspective on entrepreneurial innovation.

However, the larger corporations are not slow to move in on new ideas launched by entrepreneurs. They commission new designs and prototypes from small R&D teams (a growing source of opportunity for these enterprises), they assimilate and adapt technologies from new companies as well as producing their own, as Schumpeter predicted.[11] Interactions between new ventures and established companies constitute essential channels of diffusion of the new technologies, one reason why researchers at the Science Policy Research Unit have found that the very largest and very smallest firms are the most innovative in the economy (Pavitt 1983; Pavitt, Robson and Townsend 1987).[12]

Timing is crucial

As technologies emerge and are assimilated, circumstances change very rapidly. Innovations cluster as competitors move in on a new opportunity. In the early part of this century, there were over 300 entrepreneurial companies making automobiles in the USA. Similarly, there were dozens of micro-computer companies each with their own designs in the early 1980s. But the micro-electronics industry has matured much more rapidly than did the automotive industry. Rapid change characterises today's high tech industries. Once a technological opportunity has proved promising, competition will ensure that new products have short life cycles. As a technology is assimilated, companies that achieve major market share will be able to promote the design that becomes the industry standard. The competitive advantage of new companies lies in their initiative and flexibility; because they are made up of small teams, they can be more rapid than established companies in spotting opportunities, in converting ideas into designs, designs to products and at getting products to market. Early entry may be necessary to avoid the intense competition that arises as the

[8] Rothwell, R, Zegveld E, 1985, *Reindustrialisation and Technology* Macmillan, London.

[9] Tushman M, Anderson P, 1986, "Technological Discontinuities and Organizational Environments" *Administrative Science Quarterly* 31:439–465.

[10] The spend on R&D in relation to dividends is much lower for UK than for leading international companies: "The results published in this Scoreboard are mostly disappointing" p3 in CRL for the Department of Trade and Industry, *The 1996 UK R&D Scoreboard.* And "In 1994 the companies distributed twice as much in dividends as they spent on R&D. Among the top 200 international companies, R&D spending was nearly three times the amount allocated to dividends" *The UK R & D Scoreboard 1994,* p1.

[11] Schumpeter J, 1928, "The Instability of Capitalism" *Economic Journal* Vol 38, 151:361–386.

[12] Pavitt K, 1983, Characteristics of innovative activities in British industry, *Omega,* Vol 11, pp 113–130; Pavitt, K, M Robson and J Townsend (1987) The Size Distribution of Innovating Firms in the UK: 1945–1983, *The Journal of Industrial Economics,* Vol 35 No 3, pp 297–316.

technology spreads. The race is to be among the firms that will set the industry norms or standards. High tech firms must be organised in such a way as to be rapid movers. This is where the small size and focus of the new venture gives them competitive advantage. They are fast learners. Older firms experience "lock-in" as a result of past commitment of resources, and may require radical restructuring to adapt to new opportunities.

Institutional Inertia and Innovation

Financial innovation is essential if technological innovation is to be diffused and rewarded. This requires that investment reach new ventures as well as established firms. The financial sector determines along which channels and at what rate savings will be directed into investment in new areas. In many aspects the UK financial sector has proved innovative, and venture capital has formed to fund emerging technologies. But it is difficult for investors to pick up signals as to where are the promising directions for the future. The inclination is to fish in familiar waters rather than venture forth into unknown seas. In many respects, the venture capitalist is in the position of the investors of old, selecting a ship to back. A good captain, a sound vessel, a promising route—and the ship promises to return laden. But who can know what rough seas and high winds, what brigands and battles will be encountered?

In attempting to "pick winners" venture capital faces a daunting task. The profile of "winning teams" is at once clear and elusive:

(1) The founding team includes both experts on the technology and also people with experience of the industry in which it is to be applied. This team must have a strong drive to grow the company.

(2) Their technology meets a perceived need or solves a problem at a viable level of performance and cost.

(3) Customers can be reached who will be prepared to pay the necessary economic margin.

It is not possible to be certain of the second or third sets of factors in advance, but the first set of factors is the key to success since a good team will be addressing these issues intensively. The risk attached to investing in firms that initiate and diffuse significant innovations can be diminished under the following conditions, which involve building up expertise in the management of funds for high technology investment:

A. Investors hold a portfolio of funds which, whether specialist or generalist, is varied in certain key respects (eg size, term, novelty).

B. Investors have access to extensive knowledge of the opportunities and prospects for the new product or process.

C. Networks of producers and consumers are creating opportunities for, and learning from, each other in the initiation and diffusion of related innovations.

Currently, as the Bank of England report on finance for small technology based firms shows, financial innovation lags behind technological innovation, reducing the funds available to promote new activity. Experimentation and diversity are required to find new ways to finance emerging industry.[13]

Emergence of a New Technological System?

The importance of investing in emerging firms and technologies may extend beyond the wealth and jobs these can create directly; more extensive investment of this order may well be essential to economic renewal. Suspicion surrounds new technologies, as in the days of the first industrial revolution, because to start off with, emerging technologies tend to be used to do what is already being done at lower cost by automating production and so eliminating jobs. New technologies are therefore perceived as causing unemployment. However in the past, as new technologies have been assimilated, they have opened up new areas of activity and created new work. A "new technological system" emerges as a whole cluster of inter-related infrastructures, technologies and consumption patterns come into interaction. It can be argued that the information-communications revolutions is on the brink of forming a new technological system, but that institutional inertia is delaying its emergence.[14] Some thinkers refer to past experience to identify the importance of infrastructure and falling costs to promote currently emerging technologies. The electric grid and metal road system had to be laid down to promote the inter-related mass production industries and mass consumption system associated with electrical power and the internal combustion engine. There was a period of massive unemployment in the 1930s as the old industries were displaced, and when new patterns of production and consumption were not yet in synchrony. However, when the various elements come together to form a new technological system, productivity improves to the point where costs and prices can fall, so setting off widespread demand for new products that can meet users' needs in new ways, as occurred in the

[13] Garnsey E, 1995, "High Technology Renewal and the UK Investment Problem", *Journal of General Management*, Summer 1995, Vol. 20 No. 4:1-22.

[14] Freeman C, Soete L., 1996, *Work for all or Mass Unemployment? Computerised Technical Change into the 21st Century*, Pinter Publishing, London.

post world war boom. Under such circumstances, a variety of new opportunities interact, creating further possibilities.

In advanced economies, massive reductions in employment have taken place first in manufacturing, then in the financial sectors, as a result of technical and organisational change. In the micro-electronic revolution, lay-offs, eg in the financial sector, are blamed on IT. But interconnecting technologies and infrastructures can allow new sets of activity to take place to meet users' needs in new ways. When the prices of the innovations fall sufficiently, they can become accessible to whole new categories of users, who have latent demand for education, recreation and other provision facilitated by new technologies. As these products and services become increasingly accessible and affordable, multiplier effects should expand demand sufficiently for emerging technologies to become a source of new jobs, as has occurred in previous great technological shifts. There are signs that this is occurring. Cable and internet connections are at last fast diffusing. Prices in the computer industry have fallen steadily as productivity and functionality have increased. In the service sector, innovations allowing user-input (self-service) have reduced costs. For both new goods and services there is very extensive potential custom represented by unmet needs which could be translated into effective demand as costs fall and incomes rise. Indeed should a new economic wave set it, the critical constraints will stem from the environment rather than from demand, requiring a complete reorientation of activities towards sustainability.[15]

If the new technologies are to give rise to new areas of activity, new patterns of production and consumption must move into synchrony, and take a form compatible with environmental needs. High technology enterprise by innovative firms, including new ventures, which introduce innovations and assist in their assimilation, is essential to overcoming the inertia which characterises established forms of economic activity. The problems faced by high tech enterprise in effectively fulfilling their role in the economy, point to institutional rigidities especially in finance and education.[16] These contribute to the mismatch between innovative potential and social and political structures. In acknowledging the needs of high technology enterprise, we must recognise the need for changes which have long been resisted.

January 1997

Examination of witnesses

DR ELIZABETH GARNSEY, Lecturer, Judge Institute of Management Studies, Cambridge University, and MR PHILIP LANGSTON, Chief Executive, Cambridge Quantum Fund Ltd (specialising in seed capital for innovative ventures), were called in and examined.

Chairman

63. Dr Garnsey, Mr Langston, thank you for coming to give evidence at such short notice. Dr Garnsey, I gather that you are going to start us off with a presentation, is that correct?

(*Dr Garnsey*) A few words perhaps, my Lord Chairman.

64. May I ask you whether you would first like to introduce yourself and Mr Langston?

(*Dr Garnsey*) I teach management studies to engineering students at Cambridge in the new management studies institute.

(*Mr Langston*) I run a small seed capital company in Cambridge which is owned by the University of Cambridge and by 3i. We work a lot with the university academics and try to draw technology out of the university into the "real world".

65. Thank you.

(*Dr Garnsey*) (*Slides shown*) The concerns of this Committee are to start off with the role of innovation in the United Kingdom today, which is a very, very broad area, and I thought that I would just start with a few words on the state of innovation in this country. I think that we are very good at innovating in the established industries and the industries like food processing and mass retail distribution are among the most innovative and profitable in the world. We also have a lot of innovative start up activities round the science base, so if you think in terms of the adopters of technology we are rather good at *this* end (*indicating on slide*) and rather good at innovating in the more established industries. The difficulty seems to come in moving from getting products to the early technology enthusiasts, on into the hands of mainstream customers, because there is a kind of discontinuity in markets that is not always recognised. And that really has to be addressed if these new ideas are going to move from the early adopters of innovation into becoming the source of technologies and products and services that are widely assimilated in the economy. There is no simple answer to that problem. It is not enough to say: well, we should not worry about this sector, the important sector is the mainstream. Because just as science is the seedbed of innovation, so the early activity among firms with new technologies and new ideas often drawn from the science base is required if we are going to have the companies with the expertise to anticipate, to see out on the horizon the areas where there will be growth. The little companies experimenting with technologies are ensuring that we get teams of experts built up who know about the

[15] However the translation of latent demand into effective demand for new technology based goods and service requires spending power which may be curtailed by inequitable distribution of income.

[16] Elsewhere we have described an innovative programme at Cambridge University (Gregory M, Garnsey E. 1997, Bridging the Gap: Innovative Education and Research in Manufacturing, Written Evidence to the Select Committee of the House of Lords on Science and Technology).

Chairman *contd.*]

technologies that are going to be important, and it is often very difficult to anticipate in advance what these sectors will be. It is those experts who can spot the opportunities who are going to be able to ensure that there are companies in a position to move into the mainstream. However, for the time being there is a certain gulf there, that turns out to be very hard to cross, and it is interesting that the management expertise which ensures that there is so much effective innovation in particular in food processing and mass retailing could be brought to bear on the rest of the economy. Let me give an example taken from computers. British computers got computer firms into schools very early and they have been there for 15 years now, but they have not in many senses moved beyond the technology enthusiasts and the early adopters. The IT teachers, the technology enthusiasts in the schools, use the computers and the rest of the teachers toil away by hand as they always have, the reason being that our companies tend to expect users to make the effort to meet them rather than making the changes which would enable them to be more easily assimilated. It is those companies that deliver useable products to consumers in the mainstream who are likely to be the really successful ones.

Lord Kirkwood

66. My Lord Chairman, may I ask what the vertical scale on there is?

(*Dr Garnsey*) Market expansion.

Chairman

67. Mr Langston, is there anything that you would like to add at this point?

(*Mr Langston*) My Lord Chairman, not at this point, no. I am here very much as counsel to Elizabeth Garnsey and I will contribute as and when you ask me to, if I may.

68. Do please feel free to give an answer whenever you would like to join in.

(*Mr Langston*) Yes, thank you, my Lord Chairman. I am not an academic, I am a practitioner so what I say is not backed up by good research; it is backed up by hard won experience, so when it is necessary perhaps I will chip in.

Lord Cuckney

69. With regard to the discontinuity that occurs that you have illustrated, what do you perceive to be the causes of that? Is it the funding problem at that stage?

(*Dr Garnsey*) Yes, my Lord Chairman, there are causes from a number of sources. Certainly there is a problem with funding which is very well set out in the Bank of England report on the financing of technology-based small firms. There is also the fact that if that discontinuity is to be bridged firms have to think from the start about segments of users, they have to target those users and work very closely with them to understand their needs and problems so that they can deliver a solution to those problems and there may not be the vision to see the need to move into the mainstream in that way, partly because it is difficult to anticipate and partly because it is costly to function in that way and drip feed finance such as is available to most firms does not encourage this sort of vision.

70. How much do you think it is a weakness of management because one has observed in the growth of companies this well known disease of "plateau-itis" where they get up to a certain level and then they cannot get off it because of lack of vision and managerial qualities and so on?

(*Dr Garnsey*) Again, my Lord Chairman, there are a number of problems. One of the reasons for companies plateauing is because they are a niche market and they have found as much custom as is available in that niche market and playing safe with funding in particular does encourage firms to go into niche markets. To diversify and to develop new products, which is what is required to go on growing, requires further funding, that is, development funding, and that may not be available. Another problem is internal management problems. Very rapid growth is difficult to co-ordinate, it creates problems of overload, it creates bottlenecks, and we found that a number of companies grow very rapidly and look very encouraging in their internal dynamics only to run into growth reversal problems as the co-ordination of growth becomes a problem in its own right.

(*Mr Langston*) My Lord Chairman, perhaps I may add a little bit there again from practical experience. It is that one of the limiting factors in small companies becoming large companies is that the entrepreneurs themselves are often modest in their expectations and are willing to say, "When this company is worth £X million and I am worth £Y million I will sell to somebody else." They do not have what we sometimes believe is the American outlook which says, "I want to be a hundred million or a billion pound company". They say, "I am quite happy and earn enough money to buy myself a good country house and put my children in good schools and when I have got there, that is enough for me, thank you", and it is an attitudinal thing which is, of course, very, very hard to change. I hear this frequently from people who come to us for money, they say, "We want to get this company up to a certain size and then let someone else take it on—I will take my money and run".

(*Lord Dixon-Smith*) My Lord Chairman, I understand the sentiment extremely well, and I understand people wanting to take the money and run, but if you have got a product which potentially can go on, then, of course, it is a question of finding the right buyer. However, the real question, it seems to me, is how do we tackle this attitude question, how do we set about if you like changing the psychology of people so that if they create an opportunity—and some of them create opportunities quite inadvertently, and we have to face that fact because it is how things arise—how do we create the culture to persuade people to take these things forward and to have a vision that even if they do not want to take it forward themselves they should put it into the hands of people who will?

Chairman

71. If I may just follow up on that, is it attitude that we should be trying to address or is it just easing that process of transition? If they have a set of attitudes that are not appropriate to the next stage of the development, then is it more appropriate simply to make sure that exit is easy so that someone who has the set of attitudes that are appropriate to a bigger business then takes it on?

(*Mr Langston*) It is partly attitude, my Lord Chairman, but it is also partly the fact that the man who sets up the company often is not the man or woman to take it through to the next stage of growth and there are three or four very distinct further stages of growth in the company. You see it very frequently that the founders cease to be the drivers after a certain number of years, so the fact that they do say, "Okay, I now want to sell up and take my money and buy a country house and sell to XYZ plc" may not be a problem just so long as somebody picks it up and grows it. However, we do not have many people around who can go all the way through and make a number of billion pound companies. There are very few people like that around.

(*Dr Garnsey*) But, my Lord Chairman, we are seeing some entrepreneurs with that spirit.

Lord Dixon-Smith] Yes, but accepting that perhaps the individual who can take it all the way is limited, are we identifying a deficiency of those who will pick it up and take it through the subsequent stages? If that is a problem, how do we set about rectifying that?

Lord Dainton

72. Is it not often the situation that a person with a genuinely new idea can become so besotted with it as to fail to realise that demand for the product is limited (High Voltage Engineering Corporation in Boston is an example) and after initial success begin to fail by not modifying the product? Are we lacking in this country the kind of person in small firms who will say, just as Oxford Instruments did, "We've come to the end of this particular phase of development but these are possible to us if we make these following slight changes"? Is that where the blockage is?

(*Mr Langston*) My Lord Chairman, I am not going to answer Lord Dainton's question directly, but I will answer it in a slightly roundabout way.

73. Oh, I am sorry about that!

(*Mr Langston*) I was going to say, my Lord Chairman, that sometimes it is a blessing that the entrepreneur stands to one side because he does sometimes, as you have described, hold on to the technology and regard the whole thing as his. When he moves aside and more professional management comes through is when we get the next level of growth, so sometimes it is to be welcomed. We should not berate entrepreneurs for working very hard for two or three years and then stepping aside: it is a good thing frequently.

74. But that was not my question. My question was the other way round, of course, that the person who is so besotted with the idea does not welcome the development because he still believes in it.

(*Mr Langston*) Yes, my Lord Chairman, and there are problem cases where you cannot get the original founder to let other people into the company who are more adept at marketing and financial management and those sort of things.

75. And is that more commonly the case the closer you are to the pure science than to the engineering technology as it does seem to me among students who graduate in those subjects there is a difference of attitude?

(*Mr Langston*) I cannot draw from recent experience to answer Lord Dainton's question adequately, I am afraid, my Lord Chairman.

Lord Kirkwood

76. My Lord Chairman, with regard to this gap, this break, is something that is specifically seen in the United Kingdom? If it is, are you suggesting then that in the United States, for instance, they breed a certain sort of person who has an idea and takes it through? Bill Gates I suppose takes it right through as far as the idea can be taken. Have we lost people or is it something that everyone meets in different countries?

(*Dr Garnsey*) The evidence from the United States, my Lord Chairman, suggests that more technologists are able to grow their companies. They do give way to professional managers, but they may still perform an important role in the company for rather longer than they do here and I think that that has something to do with the greater business literacy of scientists and technologists in the United States; they have a broader education and it is part of the culture to understand business. However, we have technologists who are very successful and business oriented. Ionica is a case of a company in Cambridge with an exciting technology and a team that is determined to grow. We have cases of increasingly strategic start ups which are based on alliances and are undertaken with the view to reaching those mainstream customers, so I think that some of this problem is already being remedied, my Lord Chairman, and the culture changes as the entrepreneurs gain more experience and give an example of success to others. If there is reluctance to carry on beyond that plateau it is partly because entrepreneurs have seen friends and business associates come a cropper. When they see success there will be more enthusiasm for the task. That has certainly been the case in the United Kingdom.

77. Success breeds success?

(*Dr Garnsey*) It does indeed.

Lord Dainton

78. May I ask just one question based on the Cambridge experience, and it is this, my Lord Chairman. With the vast number of companies, some of them occupying common sites, whether it is yours or Trinity, do they gain from one another in experience and learning? John Bradfield suggested that they did not at all. Is there any value in clusters of this kind?

(*Dr Garnsey*) My Lord Chairman, I think that there is very great value in clusters of this kind. They may not interact directly with each other in trading

Lord Dainton *contd.*]

terms, but they are part of a business culture which enables them to keep tabs on what is happening and they learn a great deal from each other about management and in similar areas about markets. It does seem that a critical mass of firms in associated areas is beneficial, and in Cambridge we have a very diversified set of companies, so one of the things that John Bradfield may have picked up is that at an early stage with these very diversified companies they were all learning in their own way and in their own direction, but as they become more numerous and cluster to a greater extent, there is evidence of learning going on among the firms.

79. So, to put words in your mouth, you would encourage the development of clusters even by external stimulus?

(*Dr Garnsey*) My Lord Chairman, these have been largely self-organising clusters, but they have been stimulated by investment in science, investment in technology. The introduction of the computer aided design centre in Cambridge has been the root of a whole set of computer aided design and geographic information systems companies in Cambridge, so that investment by the Government in the computer aided design centre in the late 1960s has more than paid off in revenue back to the Exchequer.

Lord Currie of Marylebone

80. How far do you think that this discontinuity that you described arises from, as it were, innovators who, as you say, are too little versed in business and on the other hand handing over to professional management who are too little versed in fundamental science and engineering—almost two cultures of education?

(*Dr Garnsey*) There is a need for teams who are multi-skilled and in those teams business awareness and a very good understanding of technology are equally important. You need the technical skills all the way through because only the technologists can understand the potential of their products and hence what problems they can solve for users. You also need the business acumen from the start, particularly if the companies are going to think big and target segments of the mainstream market so what is required is to encourage teams to be multi-skilled, and I think that the venture capitalists perform an important role there in ensuring that teams are balanced as one of the main objectives.

Lord Dixon-Smith

81. The immediate question that flows from what you have just said is, are there links between the business courses in Cambridge and what I would call the technology courses and the science courses going both ways so that, if you like, the culture of one is to a limited extent none the less a part of the culture of the other; and, if not, why not?

(*Dr Garnsey*) My Lord Chairman, in Cambridge at large there are very large numbers of seminars, workshops, activities of various kinds, that firms attend. They network in attending these seminars, short courses on marketing and so on, so there is a whole culture of workshops available to managers. Within the university the engineering department has pioneered teaching students about the business world as well as about technology and we have in engineering a number of courses for aspiring entrepreneurs to introduce our engineering students to the idea of starting up their own company or working in small companies. The science departments are more purist. They do not on the whole put on business courses, but once scientists get into companies there are a lot of courses that they can attend.

Lord Dainton

82. As the person whose name is attached to these courses (because they were not the idea of the university but of the University Grants Committee which invited universities to tender for these courses in 1977) I was interested in what happened to them not only in Cambridge but in Oxford, Brunel, Manchester and so forth, and the interesting thing that came out of that on which I would welcome your comments very much is first that they got very, very good students for that—four years, tougher, but they did attract good people. By and large an analysis was done that they tended not to go into this technological side of employment but into the business side; they were in a sense lost. Whether they have come back I think that it would be well worth knowing because such people could be invaluable in this area about which we are concerned. Do you know anything about the Cambridge policy?

(*Dr Garnsey*) My Lord Chairman, I teach manufacturing engineers on the manufacturing tripos and many of them do go into manufacturing within a very short time—we certainly encourage them to go into manufacturing—where many of them become production managers at a very early age responsible for millions of pounds worth of equipment and they come back and tell us about what is happening, and it is very exciting. Others go into various aspects of management, some do go into consultancy and into the City: they are snapped up because they have this rounded education with scientific and technical training and business training. There are not enough of them to go round.

83. What proportion of them go purely into the finance side? A very high proportion in other universities.

(*Dr Garnsey*) I would have to check the alumni record, my Lord Chairman.

84. It would be very interesting to know.

(*Dr Garnsey*) I do not want to get the figure wrong.

Lord Dixon-Smith

85. Is the culture, if I may put it this way, of students which would apply both to those in management and to those in the engineering and science disciplines who try to find themselves a job which if you like has a reasonably high level of safe and secure salary not of itself a psychological predisposition against the sort of entrepreneurship that is required to get these business start ups going?

Lord Dixon-Smith *contd.*]

(*Dr Garnsey*) My Lord Chairman, it must be said that there is a different sort of culture in Silicon Valley where graduates find it positively embarrassing to work for a big company—you know, "What's someone like you doing in IBM" is the kind of culture that applies in Silicon Valley, and we have a way to go to reach that sort of outlook. Students are drawn to the blue chip companies and I am sure that the blue chip companies are very pleased to be able to attract the best students, there is no doubt about that, but we also have very good graduates in the high tech firms around Cambridge and increasingly they are able to offer very attractive career prospects to graduates.

(*Mr Langston*) My Lord Chairman, may I just add a little there because from my experience the most successful people that we support are the graduates who have left university and gone, for example, to Procter and Gamble or ICI for three or four years and then have come out of there; they actually have gone through a second level of learning with a large company. The ones who come straight from university into entrepreneurship sometimes get it right but more frequently are so inexperienced that they do not get it right. Therefore, I encourage people to come to me a few years after they have been somewhere else to learn some pretty hard lessons and some good lessons too with some major companies. They are better when they come back.

Chairman

86. Dr Garnsey, your earlier mention of the diversity in Cambridge, the loose cluster, leads me on. We use the term technology very loosely in these kind of discussions. If we were to focus on science based start ups and the high tech sector and these are represented as requiring special consideration for their role in an innovative economy, what is this special role of this narrower group?

(*Dr Garnsey*) My Lord Chairman, I think that that is an important issue because the excellent report by the Bank of England which is informing our discussion actually does take as given the fact that these companies have an important role to play in the economy. On the other hand, I often encounter the view among Business Links as well as elsewhere that high tech science based companies are a kind of aberration, they are elitist, they are boffin companies and they do not have a lot to do with mainstream business. So there is a sort of disjuncture there between the assumption that they are so important to the economy and on the other hand feeling that they are a rather narrow, elitist area. Without espousing either view, my Lord Chairman, I could perhaps rehearse what is very well known to all members of the Committee which is the way in which innovations impinge on other companies in the production chain. This I think is the key of understanding the importance of this sector. (*Slides*) If we thought about the electron microscope, for instance, an innovation that was based on science in the 1930s and 1940s and was introduced into laboratories more than 20 years later, the introduction of the electron microscope was fed by knowledge from national laboratories and from the universities. As they became commercialised they fed back into these sectors and made possible many of the breakthroughs in biology that have had so many important industrial applications. Therefore, there is this interaction between science and technology and the commercial development of instrumentation which is mirrored in software and other sectors. If then you imagine a firm that used to produce light microscopes and is finding the market limited—after all, electron microscopes have 500 times the resolution of light microscopes and they are not limited by the wave length of light. The market then is expanding for electron microscopes, they decided to diversify or to change their product range. They are immediately going to impact on a whole set of suppliers as well as on their customers—the police force which may change their forensic methods and so on—so that innovation in this area has the effect of opening up opportunity space, as it were, all round it, in a way which does not occur to the same extent if you invest, say, in a dairy, in pasteurisation. Now pasteurisation is a technique that has been fully assimilated into the economy so if you invest in a dairy, as 3i recently did to £7.6 million, you may create knock-on effects for the local economy, but you are not opening up opportunity space in the same way. These companies that generate innovation around themselves are also creating expertise and that is the expertise that will make it possible to move into the new areas that are opening up. This then is why high technology is important, not because it is glamorous or close to science, but because it uses knowledge in new ways and so creates these knock on effects in all directions. Of course, my Lord Chairman, the large companies may hold back a little from innovations that create so much uncertainty around them. They may prefer to let the little companies initiate the innovations and buy them once they have proved to be successful. It is not an accident that IBM did not produce the microcomputer, that Kodak did not produce the photocopier; each time it require the start up of a small entrepreneurial firm to initiate the innovation that then had these knock-on effects.

Lord Dainton

87. Indeed, there are cases, are there not, where something that is likely to destroy mainstream product of a firm like Kodak would be suppressed by buying rights in order to prolong the life of its mainstream activity?

(*Dr Garnsey*) There are unfortunately cases of pre-emptive patenting or purchase of companies in order to suppress rather than develop the technology.

88. Which brings us back to the need for truly free venture capital to be able to invest in these things to ensure that they have a start, and who is going to judge what is the right decision to make there?

(*Dr Garnsey*) My Lord Chairman, it is a very difficult decision and one can see why the institutional investors pull back, guarding their savers' money from being placed in the hands of uncertain companies. However, looked at from the aggregate point of view we have the situation where investors are keeping guard over, say, our pension

contributions, and these funds are failing to get through to the companies that are capable of creating the jobs for our children. So there is a certain stickiness there in the channels for savings getting through to the new areas.

Lord Currie of Marylebone

89. But is there not a vicious circle? You talked about the discontinuity and we talked earlier about the, if you like, objective factors that hold back the transition from small to larger scale operation and financial markets might be quite sensibly taking those factors into account? If one could break through those protective barriers, the diseconomies of scale, the problems of pulling together the marketing, finance, human resource management skills that a larger scale operation needs, if those objective factors could be overcome, then presumably finance on a larger scale is more likely to be forthcoming? Therefore, I wonder what things one can do to overcome those factors which are internal to the operation of the company?

(*Dr Garnsey*) My Lord Chairman, there is clearly room for much improvement in the internal management of these companies and a lot of work is going on to understand what sort of management processes are appropriate. Clearly very large company processes are not particularly appropriate to entrepreneurial firms. We can see that when large firms acquire small firms they can stifle the entrepreneurial and innovative spirit in the companies that they take over. The need to find the right sort of processes to encourage creativity while instilling the discipline of the market is very difficult and very important. But I suspect that however successfully managed these companies were there would still be a large element of uncertainty because we are dealing with complexes of activity which are highly interactive. (*Slides*) If you generalise beyond this to production chains in general, if this company changes its output that is going to impinge on those who buy its output, on the customer. It is going to knock that effect onto suppliers. Therefore, a whole set of new interactions will be created. Technologies are not isolated, they are interactive, particularly in information and communications technology, and it is just very difficult to predict what those chains of action and reaction are going to be. Innovation systems are complex and dynamic systems. Complexity studies show that you cannot predict specific outcomes in complex non-linear systems. You can understand the processes, but you cannot predict specific outcomes.

90. Can collaborative arrangements help to overcome some of these difficulties?

(*Dr Garnsey*) Collaborative arrangements can help a great deal because the kinds of product that are produced in these new areas often require compatibility, so in order to deliver that useable product into the hands of the consumer you very frequently need a collaboration between companies that can provide various interactive components, and by setting up those collaborations in advance companies can ensure that they are moving into the mainstream, targeting those segments with the useable "plug-in-and-play" product that no one firm could provide but together they may be able to provide.

Lord Dainton

91. I wonder whether there is any information available on the question of the effectiveness, the success, of innovation carry-through from different subjects, and you mentioned yourself the science area, and the other, the engineering area, by saying that it was easier in the engineering area, if I understood you correctly. Are we losing something, if that is true, from the science area, and can anything be done about it? Perhaps my statement is wrong?

(*Dr Garnsey*) Perhaps Lord Dainton could just clarify what it is that we might be losing from the science area?

92. For example, it is the easy thing in chemistry, which just happens to be my subject, to go into the large firm on the whole and put your ideas and get them developed there, but now the situation is changing with firms like Oxford Molecular and so on producing chemicals by design and wanting to look for people to take them up, not being employed in a big firm, which in my mind is analogous to the problem that we are discussing which is very evident in engineering where you get incremental improvements which you are trying to develop, new ones, which are a threat, of course, as you have just been explaining, to suppliers and the problem of getting them into the market. Chemistry is really in a quite different category, it seems to me—already you can have some of those questions answered, so are there differences between faculties? You have told us that the scientists are very much unreceptive to the notion of having their courses enlarged in the way in which the engineers are, and I am wondering whether there is something that lies behind that?

(*Dr Garnsey*) My Lord Chairman, scientists protect basic science quite correctly. Basic science must be the seedbed of future innovation as well as being valuable in its own right. They are reluctant to see their courses diluted, and again one can understand that; they feel that they have a great deal to teach their students and they do not want their time taken up with other subjects. Because of the priority of basic science I think that it is only right that scientists should be in a position to make the decision about their courses and it would not be appropriate to dictate to them what they should teach. But at graduate level—and I have been invited next term to talk to semi-conductor physicists—there is an opening up of awareness of opportunities; that it is not necessary to go into the large company with large labs but there are now opportunities for starting up your own business and working in small businesses. I think that scientists are very well aware now of opportunities that were not available 10, 20 years ago, say.

93. But it is possible to innovate, is it not, without creating a new company? I think of cephalosporin which was a world beater as a drug and not only made a fortune for Abraham but also made a fortune for the firms which manufactured it? Is there a failure of transfer in engineering of ideas getting into big

Lord Dainton *contd.*]

firms because it represents a bigger threat to their mainstream activity whereas in chemistry it is a simple add-on, and the pharmaceutical industry has been notably good in this country in this respect, I think you would probably agree?

(*Dr Garnsey*) Yes, my Lord Chairman, the case of the pharmaceutical industry is particularly interesting and perhaps it can clarify some of the other issues that you have raised. This is a subject of special interest to my colleague. The British pharmaceutical industry are very well aware of the importance of science based knowledge. They are very keen to access this knowledge by creating alliances with the small companies that can provide them with intellectual property. They outsource, they set up alliances with them, they provide them with credibility, which is very important for their obtaining funding, so there is a pull through there from the pharmaceutical companies, with new advances in biology being encouraged to take this route. There is also success in that area because the markets are large and the prospects of profit are good. Finally, my Lord Chairman, there is an important point which I should like to ask Phil Langston to point out because he has seen this in his companies, to do with the regulatory regime within which pharmaceutical companies operate. It is quite interesting to see regulations promoting enterprise rather than merely controlling.

(*Mr Langston*) My Lord Chairman, as you probably understand, in the pharmaceutical world to take a new chemical entity through to the market place, that drug needs to go through a number of regulatory hurdles. They are very discrete, very distinct and very well understood. At each point that a drug crosses one of the thresholds, the company makes an announcement, its value goes up and everyone gets very excited. Now from an investor's point of view, my Lord Chairman, that is manna from heaven because this is a long term project—taking a drug from new chemical entity to market place can be ten, 12 years. It is a long time to wait for your judgment, your early investment decision, to be vindicated, so if you can see it as what I might describe as a staircase of increase in value, independent regulatory world class bodies validating the scientists' work and therefore your investment decision, that helps you along the way as an investor. I cannot think of any other sector, and especially not engineering, where there is a similar framework. This industry is unique, I think, and you combine that with the pull through effect that Elizabeth Garnsey referred to, big business feeding off the knowledge of smaller companies and academics and put those together and have a large world market—it is a superb opportunity, and this is why we are seeing currently the biotech sector being so successful in raising money. I cannot think of another sector which has those unique features to it, my Lord Chairman. It is a very special case.

94. May I just ask, my Lord Chairman, is that why, of course, those large companies by and large are so willing to put very substantial sums into universities where they think that there is skill?

(*Mr Langston*) Yes, indeed, my Lord Chairman. Lord Dainton says that they are substantial sums; they are in seed capital terms substantial sums. If Glaxo, for instance, gives £3 million to a department, it is large money to that department, it is large in seed capital terms; in the terms of Glaxo Wellcome, it is small beer, so they can afford to back a number of these research groups in academia and encourage them and support them and wait for the good ones to come through.

95. And this is primarily, I suppose, because of the similarity of the activity at the bench in the universities and at the bench within the industry itself if it is to go anywhere?

(*Mr Langston*) Yes, there is an alignment of scientists both in the commercial area and in academia or in the small company. There is a great coalescence, if you like, of the scientists in both organisations. They get on very well together and usually research together and that again I think is quite unusual. I cannot think of many other examples in other sectors where you get that level of co-operation and cross-fertilisation.

96. So we should leave this sector outside our consideration, it being in a healthy state, is that right?

(*Mr Langston*) Well, it is successful, my Lord Chairman, but only in the last four, five years: it is a recent phenomenon really.

(*Dr Garnsey*) And I may perhaps add, my Lord Chairman, that a lot of these biotech firms are not yet delivering profit, many of these concerns are not yet profitable. If we think again of that divide between the early innovators and the mainstream, we could detect the need for companies that are going to deliver innovation into the mainstream. I can cite a company called Quintile International which was founded by British scientists, a US company, which specialises in the management of clinical trials. Now that is accrediting the research and development coming from the science base or from small companies that have sprung out of the science base and delivering these new ideas into the hands of the large pharmaceutical companies that then will pay substantial rewards commensurate with the rewards that they will achieve from these new developments. Therefore, we also need companies that can cross that divide.

97. So that facilitates getting FDA approval essentially?

(*Dr Garnsey*) By managing clinical trials, yes, but it is that sense of where the opportunities lie to get a useable product into the hands of the customers which is the key to success of that type of thing.

Lord Dixon-Smith

98. My Lord Chairman, if I may, I want to change tack and tie this into the question about Cambridge being successful in generating innovative firms based on ideas originating from the university. I wondered whether in fact this was a deliberate decision, a strategic view by the university. The question was the result of a conversation that I was having with some academics last night. They were saying that the way that their research is funded at the present time actually prohibits any possibility of taking a strategic view. Most of the research is done, as Lord Dainton

Lord Dixon-Smith *contd.*]

well recognises, on the basis of short term contracts and, if you have a contract for your research which lasts for a year or 18 months or whatever, you get halfway into it and then you are immediately spending your intellectual effort on working out how you are going to get your next contract so that you can continue your research! I do just wonder if this what I would call culture of short termism that that engenders is an inhibiting factor towards people taking what I would call a strategic view of the products that they are trying to come up with?

(*Dr Garnsey*) My Lord Chairman, I have heard Japanese visitors express astonishment that British science is being subjected to the methods of industrial management because they have admired the self-organising nature of British science and its spontaneous organic growth in a very cost-effective manner. So, yes, the extent to which scientists have to expend their energies continually competing for funds from the research councils does perhaps militate against both the organic growth of ideas and expertise and also perhaps strategic thinking as to where next to go. The dictates of the research councils are to an extent influencing the directions of research, and it may be that that is beneficial and brings about economies of scale and clustering of activities and so on, but the noble Lord is right to raise that point. As for whether the university had a strategy, Cambridge University is itself a kind of self-organising system which has created a culture that is a very high trust culture and a culture that is open to enterprising activities, and I think that this has been a main contribution of the university, in addition to the fact that the university did not claim title to the intellectual property of inventors. Since the research councils do that it has not made all that much difference in practice, but it is symptomatic of a high trust environment in which the university staff are encouraged to be innovative, and have been, in wide ranging areas.

99. But Cambridge University has a fairly unique structure—well, I suppose that Oxford may be similar and London, which is reduced now to a state of anarchy. I have a friend who is on the finance committee of Cambridge University and he asked for a report on all the financial arrangements at the university and found that there were I think 270-something or 230-something finance committees, all sub-committees of the main one, and I think that there is no, as there is in most universities, what I would call central organisation running it. It is a very diffuse federation, if I may put it that way.

(*Dr Garnsey*) And only 2.7 per cent of the budget goes to the central administration, so it is a very cost effective structure.

Lord Dainton

100. It depends how you judge their effectiveness as a central administration.

(*Dr Garnsey*) Yes, indeed.

101. If I may pick up on the point that you made about Japan, it seemed to me—I was involved in that early on—that the fundamental difference between Britain and Japan was the great understanding between MITI, the Ministry of International Trade and Industry, on the one hand and Monbusho, the education department, who worked together and saw that they had to create an atmosphere in which longer term research was possible and protected within the universities but also well taken up by MITI. Is that a wrong analysis?

(*Dr Garnsey*) My Lord Chairman, yes, there is no doubt that MITI has done a great deal to provide the impetus and capital that has been the root of Japanese industrial success.

102. Should we be trying to emulate them or is it too late?

(*Dr Garnsey*) The Japanese are at the moment trying to catch up with us in terms of technology enterprise. They are supporting research in laboratories; for example, we have their Hitachi laboratory, we have their micro-electronics laboratory in Cambridge, and they are also acquiring British high tech firms in order to acquire their expertise, so they are trying to learn from us in a very open-minded way, and perhaps we should be as open-minded towards what we can learn from them as they are to what they can learn from us.

Lord Cuckney

103. When an innovative start up firm has matured do you think that it continues to have special characteristics which require special consideration or do you think that it should then be treated like an ordinary company?

(*Dr Garnsey*) My Lord Chairman, I think that that is an interesting question to end on because it brings us back to something that is the theme of our discussion, that if we are to overcome that tendency to plateau, then we have to encourage firms to build the foundations for growth and entrepreneurs to think about growth and in that case these firms do require development capital on quite a large scale so that it is not the case that they can be launched and then left to get on with it because they are going to have to introduce new products and they are going to have to target mainstream customers and that will require considerable funding.

Chairman

104. Is there anything that you would like to add, Mr Langston?

(*Mr Langston*) My Lord Chairman, in relation to the last question in particular, as I said before, companies go through various stages of growth, but that entrepreneurial spirit does persist well into its later years. You can see that in many companies which are well known household names, and I use Virgin as a frequent example of a large successful international group of companies which has a truly entrepreneurial spirit through it. You can look at many other companies of the same size which are not entrepreneurial and are not growing, so, yes, my Lord Chairman, I do think that there is a need to maintain that spirit if you want to keep growing. There is a danger that companies get to a certain size and professional management comes in and that often is necessary but it can sometimes offset or overcome that truly entrepreneurial driving spirit in

Chairman *contd.*]

a company which, actually, is not kept to one man—that feeling can infect other people, and that is a good thing that we should not let go of.

105. Dr Garnsey?

(*Dr Garnsey*) My Lord Chairman, only to applaud your interest in this area and to wish your Committee very good progress in finding the right balance between supporting enterprise and discouraging premature commercialisation of science; supporting basic science, yet encouraging those applications which have a lot to offer the economy.

106. Thank you both very much indeed for coming to give evidence to us.

(*Mr Langston*) My Lord Chairman, thank you, and may I have just one last word. This is a rare opportunity, so I would like to say just a few closing remarks on my part. I think that we are in danger as a nation of beating ourselves when it is not always necessary, and this area of seed capital and entrepreneurialism and innovation we are not bad at actually. We must not depress ourselves by saying that we are not as good as the Americans. We are getting better at it, and in the last few years there has been a rapid rise in the interest in seed capital, which I am very pleased about. If any initiative comes out of these discussions towards finding more seed capital, that is wonderful, but I would urge, my Lord Chairman, if it does come forward in some form or other that that seed capital goes into dedicated seed capital investors, not into general venture capital funds.

Lord Dainton

107. My Lord Chairman, I wonder whether we could ask Mr Langston to provide us with some factual evidence for the statement he made about the fact that we are not bad and that we are getting better?

(*Mr Langston*) My Lord Chairman, as I said at the outset, I am not a researcher. I am calling off personal experience, but we are getting better at it!

Chairman] Thank you very much indeed for a positive note to end the session on.

Supplementary memorandum by Dr Elizabeth Garnsey, Cambridge University

Bridging the Gap between Industry and Academia; An Innovative Programme in Manufacturing at Cambridge University

One of the questions addressed by the Select Committee on Science and Technology of the House of Lords has been ways of improving the links between industry and academia. Dr E Garnsey was asked to give evidence to their Lordships on 12 December 1996. They raised the question of innovation in higher education for scientists and technologists. Dr Garnsey was subsequently invited to provide further detail. Here we describe the Manufacturing Engineering Tripos and activities of the Manufacturing Research Group as an example of a successful "institutional" innovation.

The establishment of the four year "Dainton" programme the Manufacturing Engineering Tripos has provided a major stimulus to education, research and support to industry in manufacturing.

The organisers have always taken the view that manufacturing covers the full cycle of activities from understanding the market, designing production and manufacturing systems to production and business operations—all against a background of economics and human resources. Students receive academic and practical courses in all these areas, to which staff from the Judge Institute of Management Studies also contribute.

Key features of the programme are:

- group projects requiring students to undertake market research, design, production and business planning through to full feasibility;
- extensive use of industry-based assignments in large, medium and small companies to tackle problems of innovation and product introduction as well as manufacturing and business operations;
- an international outlook through language teaching and overseas visits;
- currently the course involves the integration rather than simply the acquisition of knowledge in engineering, management and economics.

In order to support the course, it was necessary to develop new methods to enable students to cope with key tasks in manufacturing including:

- manufacturing strategy and performance;
- technology management;
- international manufacturing.

A substantial industry-oriented research group has now developed, devoted to these subjects and providing practical processes for industry—particularly SMEs—as well as teaching material for students.

It is our experience that many innovations proceed from practice. Progress requires that further research incorporate the experience of practice. A thoughtful process-based approach to the development of products and processes can yield great benefits. Staff employed in the Manufacturing Group, who include people with many years of industrial experience, are well equipped to work in this way.

Lord Dainton asked some questions (82 to 84) on career destinations of students on one of the courses he was active in founding, the Manufacturing Engineering Tripos at Cambridge University. I said I would check our figures.

Career destinations of students graduating from the Manufacturing Engineering Tripos at Cambridge University from 1979–95

We have information on current career status of 76 per cent (326) of the 429 graduates of the Manufacturing Engineering Tripos between 1979 and 1995. Among these, 53 per cent (229) were in posts in industry, 16 per cent (70) were in consultancy work*, and six per cent (27) were in posts in finance. The remaining 23 per cent (103) graduates, on whom we do not have recent details on current post, include those in education, the services and other miscellaneous activities, as well as others in industry, consulting and finance. As a percentage of graduates on whom we have information the figures are as follows:

Known Destinations of Graduates in Manufacturing Engineering, Cambridge University 1979–95

Industry	229	70 per cent
Consultancy*	70	21 per cent
Finance	27	8 per cent
All with known destinations	326	100 per cent

* Many in consultancy are working on manufacturing problems.

Dr E Garnsey

Examination of witnesses

MR PENDARELL KENT, Executive Director, and MR ADRIAN PIPER, Senior Manager, Bank of England, were called in and examined.

Chairman

108. Mr Kent, Mr Piper, thank you for coming to give evidence at relatively short notice to the Committee. You are, of course, the authors of your own misfortune in that it was indeed your own report, the report of the Bank of England, which re-stimulated our interest in the area.

(*Mr Kent*) My Lord Chairman, thank you very much. My colleague, Adrian Piper, is a Senior Manager. He and Melanie Lund, who is here today as a member of the public and also our colleague, are in fact principal authors of this report. Much of the work and the detail is due to what they have been able to discover, so we are between us responsible for the report. I would like to say something in general if I may, my Lord Chairman. First of all, we are very pleased that your Committee has wanted to follow this up. This is an important part of the initial follow up to the report. We start out with the question of what has this got to do with the Bank of England at all or, indeed, with Government. It is partly historical because we have a long history of being interested in market failures of various kinds in relation to the supply of capital to the productive sector, large, small, medium or whatever. Lord Cuckney, as former Chairman of 3i, will know about the history of that institution which is an example of that interest in the past. It also features, as you know, my Lord Chairman, in the third competitiveness White Paper as an issue that ought to be followed up. We were asked whether we would do it and we agreed. We are in tune with the government effort to find out more about the issue under discussion. Although it is hard to pin it down, my Lord Chairman, we do come to the conclusion that there is market failure. That market failure is in the provision of start-up and seed capital to small high tech firms. You can generalise it and say that there is the same problem with all small companies, but it seems particularly true of high tech firms. Some of the evidence is based upon anecdote rather than any hard evidence to prove it. It is interesting however that this evidence, although anecdotal, is shared throughout several industrialised countries. It seems to be fairly general. We have used our Agents who are scattered around the country, and who are our links to local enterprise, to find out more about it, and to talk to the potential users of start up and seed capital. We get this story pretty consistently. We can even afford to "aim off" because our informants are the ones who have actually succeeded. This is because they are the ones that we can locate. If it is true of those who succeeded then, *a fortiori*, it must be true of those who are frustrated by an inability to raise the money. There is an interesting question: why and how does America do it differently. It is, I suppose, the paradigm of an enterprise society where markets should work, but they clearly have a problem, and have some public sector intervention to help with it. The conclusion

Chairman *contd.*]

that we reach is that there is a role for the public sector. That role needs to be in partnership so that it is well leveraged by private sector resources and energy. The debate now is, how do we design it; who is responsible for it; and how do we create the climate of agreement. My Lord Chairman, there are three things I want to say about the problem as we have defined it. There seems to be too little capital chasing these opportunities; there is a shortage of capital dedicated to them, so we have to attack that. There is an information gap on both sides of the relationship; the suppliers know too little about the potential users and the potential users know too little about how to talk to the financial sector in a way calculated to smoke out support, money and understanding. The last is a perennial problem and is germane to the solution; the cost of doing due diligence tends to be a rather fixed amount. If the capital needed by the borrower is too small to validate the investment put in by the providers of capital, then the lenders are just not going to do it. That is why you get a gap which seems to be somewhere between nought and a quarter of a million, half a million. It does not matter whether you say dollars, pounds or French francs: in all of those countries that is the range where the market failure seems to be most evident. That is our general thought, my Lord Chairman.

109. May I start by asking you about the initial responses that you have had to the report in the number of weeks that it has been published?

(*Mr Kent*) My Lord Chairman, first of all, we have had quite a lot of good, spontaneous responses from the trade associations which represent the potential users of capital—if you like, the people who have been crying out for it for a long time, so that is not a surprise. We have had quite a response too from the banks who said that they think that this is positive and useful. So the response is fairly multi-faceted and has a good feel as a kick-off. The main response though is yet to come and will be generated by us in conjunction with others. We have a seminar organised for January which the Governor of the Bank will chair. It will have around the table representatives of suppliers, users, Government, academics and ourselves. We then have a conference in March with the same kinds of people. We are asking them to come with a response to our report and with some ideas of what actions they think would be right to follow it up with. Quite how we take the conclusions of that forward remains to be seen. That conference my Lord Chairman, is being arranged jointly with the CBI and the Royal Society. It is thus a common effort, it is not just us.

110. Thank you, so at the moment you are in trawl mode before you come to any conclusions on the response to the report?

(*Mr Kent*) My Lord Chairman, yes.

Lord Cuckney

111. My Lord Chairman, I should like to develop the seed capital point. We have had earlier this morning in the Committee the distinction sharply drawn between seed capital and venture capital generally, and you have told us that there is too little seed capital about and that there is not a market place where the provider and the requirer can meet, there is not an exchange and the costs of due diligence are very high. Can you elaborate then on ways that these points can be met? I should have thought on availability of capital that the capital is there, but the biggest gap is the market place?

(*Mr Kent*) Maybe you could first develop informal markets where the costs are less. That is where Business Angels could most appropriately come in. Experience in the United States shows that this is a very successful route; it is so far much more successful there than it is here in financing high tech companies at an early stage. Typically Business Angels are people who know about the kinds of business that they are investing in, and the due diligence is partly in their head. They bring real knowledge of the business side whereas the due diligence done by financial institutions has to start much further back because they tend not to be experts on the technology. There are perhaps much cheaper ways of raising money. The evidence is that, at the early stage, it might be sufficient just to get the people together. The object is not so much to improve the market for money, but to improve the network which puts those sorts of people in touch with each other. If there is a question of incentives for Business Angels, that is partly being done by Government in successive budgets to give amelioration on capital gains tax and other income tax incentives. Thus, a relatively wealthy individual who has made a success of a high tech company, does have a financial incentive to choose that route to invest rather than just intellectual interest and, if you like, a sense of public interest. So part of the solution is beginning to be there. If you look at the venture capital industry of the traditional kind, it tends to be a rather high cost, high overhead business backed by resources that come from institutional investors who want relatively worthwhile returns. I am not quite sure worthwhile is the right word to use, but you know what I mean. The returns look very high, because they have to be able to absorb the losses from the ventures that do not work. Imagine that you are investing one hundred in four enterprises and one of them goes bust. You have to be able to return the capital to the investor out of the other three, so no wonder it feels unfair to the three. But it would feel even more unfair to the investors if they never had an acceptable return. You would have a complete market failure in that case. I do not see any way of overcoming that by pure market forces. You could get institutions more interested in the whole idea, and that is something which we are trying to do, my Lord Chairman. They have not shown much interest so far for all kinds of institutional reasons; reasons of inertia, and partly reasons of law. The thrust of the Pensions Act is likely to make them more conservative, not less. All those factors will mean that the price disincentive for those institutions will remain unless something is done to remove it. That might be an interesting area to pursue. In America they partly reduce the costs of evaluation and in the Netherlands too. They even do it in Germany. You can get your Chamber of Commerce to evaluate your business plans effectively for nothing, so that when you go forward to the potential provider a lot of the

Lord Cuckney *contd.*]

due diligence has already been done at someone else's expense. That might be something we could do something about. I do not know whether I have answered the question sufficiently, my Lord Chairman—Lord Cuckney really knows more about the answer than I do!

112. May I just ask about the Business Angel, my Lord Chairman. As you describe him in America, Mr Kent, he sounds very much like the serial entrepreneur and I wonder how one can try to encourage the entrepreneur to go on being an entrepreneur because you were saying that the Business Angel in America has a great advantage of prior knowledge?

(*Mr Kent*) Well, it does seem to be cultural as well as the fact that there are higher levels of wealth among the entrepreneurial class. We have discovered that in America it is patchy; it is not universal throughout the entire nation. It is clustered in places like Silicon Valley in California. There are clusters of successful businesses from which the wealth and the expertise has been created. Those are the serial entrepreneurs. You almost have there the conditions for a whole market. We are some way behind. We probably have to change the culture in quite a significant way. This has to do with levels of wealth, attitudes to risk taking, and maybe attitudes to failure as well. The penalty for failure in this country, socially and from a business point of view, is quite severe. The penalties in the United States so it seems are not so severe and people seem to bounce back. If they knew this in advance, entrepreneurs might be readier to take risks.

(*Mr Piper*) My Lord Chairman, I think also that we need to understand better how the Business Angel market operates in the United Kingdom as compared to the United States. In the United States, the Business Angel market is much more visible. In the United Kingdom, we do have some statistics which are just telling us about the tip of the iceberg. It is hard to know how much of this activity is actually taking place without ever coming through formal business introduction services of the sort that are available. That is why one of our recommendations is that we really should try to understand better how the market operates for Business Angels in the United States and the United Kingdom.

Lord Kirkwood

113. Do you feel that there is a difference in quality of the number of Business Angels per capita? Clearly it is part of the United States culture, this sort of thing, but would you say that the quality of people who propose themselves as Business Angels is perhaps higher?

(*Mr Kent*) I do not know how to answer that, my Lord Chairman. If success in high tech business has a better track record in the United States you might think that it is to do with quality, but it may be due to a whole range of factors. Among those missing in the United Kingdom to the same degree as in the United States are the university foundations and endowments which support and back people who come out of the academic world with scientific and technical knowledge, and make a real success of it. Now, if we have those kinds of people it will not be the quality of intellect or inventiveness that is the problem; it may be a lack of daring, but it may be that they do not have a ready way of kick starting. If you imagine yourself in the university environment and there were resources eager for you to make a success of them, you might be much more ready to take the plunge than if you have to put your house at risk and fight tooth and nail for month after month to try to get money. I think that it is more cultural than just a question of quality; that is my hunch.

Lord Dixon-Smith

114. I have had it explained to me very painstakingly by a number of people that of course the Americans do have the advantage of initially a much greater home market so that, if you like, anybody with an ambition to supply the domestic market is instantaneously looking on a completely different scale from here and that is an attitudinal thing that we cannot overcome unless we expand our minds instantaneously beyond our national boundaries. Do we have an institutional inertia here, and how do we tackle it?

(*Mr Kent*) My Lord Chairman, I do think that we have an institutional inertia in the large institutions. It is not only in relation to high tech start up but it is also in relation to Private Finance Initiative funding; to high yielding bonds; and to a whole range of relatively innovative things. The British institutions, so it is said, just do not seem to be interested. There is a whole range of behaviourial disincentives like the fact that they have to perform in competition with each other. This means that relatively quick yields rather than slow, patient yields are the things which help them as business managers. I do not want to get into an argument about short termism—it is not quite that; it is something a bit different.

115. I am just recalling my time as a trustee of a medium sized pension fund at one stage where, of course, we used to discuss this sort of problem, and I was very interested in the graph in your report showing the proportion of British venture capital that actually comes from the pension funds. That is on page 22 of the report and it is very interesting, particularly when you look at the Dutch, who get nothing from the pension funds. They get their money, of course, from realised capital gains, or a large proportion, which, of course, is success following success. But there is a distinction, of course, between venture capital and seed capital. Speaking as a trustee of a pension fund, our obligation to our subscribers and potential holders was to maximise our return and, you are right, we would give our fund managers instructions that they were to keep in the upper quartile of the average of their particular sector of funds or whatever it was and the result was that you preclude too much investment in this sort of risky area and although there are now no specialist venture capital funds which I suspect is the reason that we have had this pension fund subscription to venture capital it does not overcome the problem of the seed capital and how you get the business to the stage where it can operate at this level.

Lord Dixon-Smith *contd.*]

(*Mr Kent*) My Lord Chairman, may I just agree with that analysis. I am a trustee of a pension fund as well and we have exactly the same arguments where there is seldom trustee support for backing a venture capital fund which would specialise in high tech and in small. Lord Dixon-Smith is right in what he implies. Most of the green bit in the chart on page 22 of the report shows that, in the United Kingdom, a relatively high proportion of venture capital funds comes from institutions and pensions. That is because they are backing the funds doing management buy-outs and other quick successes which tend to flow out of the process of privatisation. That does not tell us anything, I am afraid, about the likelihood of making this a successful route for the problem that we are interested in.

Chairman

116. Before we lose this point may I just press you on the issue of the relevance of the size of the market. We are getting slightly conflicting evidence on this. It is a relatively easy thing to say about the comparison between the United States and the United Kingdom that you need a large market in which to launch; on the other hand, the process has been described at the same time as one of finding a niche market, which suggests that you maybe do not want to be exposed to a huge market very early on. Is it really a problem, the size of the market? Does the single market programme address that problem, if it is a problem?

(*Mr Kent*) Again, my Lord Chairman, I am not really sure that I can answer that question. It is often said that the United States market is easier to access because the willingness to innovate is not only on the supply side. It is on the buyer client side. Clusters of business apparently spin off from just being close to each other. In California, Silicon Valley is much larger than the Thames valley or Silicon Glen in Scotland. It is correspondingly easier to do the legwork; to beat a path to every door. There may be something in the size of the market, but in the US I do not believe it is the whole key. It is rather a matter of having viable niches.

(*Mr Piper*) My Lord Chairman, if I may just add to that, I think that in our discussions with seed capital firms we did find that they attach great significance to financing entrepreneurs or businesses that did have an international market. We had only one example given to us of a seed capital firm that was prepared to finance business that had just a UK market, and that happened to be because it was in the business of delivering a technological software product that related to 'A' level and GCSEs and this clearly was specific to the United Kingdom. In every other case the prime requirement was an international market, not necessarily the United States but certainly an international market.

Lord Dainton

117. My Lord Chairman, may I just ask one question on the reference to these peripheral units outside universities and their effectiveness in the United States. I was once a professor at MIT, and it was generally held there that the existence of those units on the MIT campus automatically gave a kind of cachet to those within MIT or, for that matter, in Harvard or Boston, who wanted to get out and to get money on the market. Assisting that, of course, in that area was a large number of fund managers in the Boston area which made it possible, and I have heard from the Registrar of Stanford that the existence of the Stanford Research Institute and Research Park were important. There is not anything really like that in this country. In your view is it important and would it be helpful?

(*Mr Kent*) My Lord Chairman, there is no doubt that it would be helpful; in that sense, it would probably be important as well. It is not as though there is nothing here—we do have the beginnings of it. In Cambridge you have science parks, Oxford does too. The Treasury set up the Enterprise Panel to look at so-called incubation units which are really another variant on the theme. The Panel found that there was more being done but sometimes with a different label. Again I think that it comes back to levels of wealth. Those foundations in the USA are immensely wealthy. British universities traditionally, in my own personal experience, have been much less good at raising capital from their successful alumni. In the United States it is an industry in itself, and that is where a lot of that seedcorn comes from. They almost intermediate, do they not, a kind of venture capital?

118. May I just ask, is the information published about the British pseudo-activities?

(*Mr Kent*) Yes, my Lord Chairman, there is a report that came out.

(*Mr Piper*) My Lord Chairman, it is the report of the Enterprise Panel which came out about six months ago, and it does cover that. I sit on the Enterprise Panel myself. It is a report which I think would be of interest to the Committee. It is not specific to technology-based small firms; it does talk about the business incubation process as a whole, but large parts of it are relevant to the type of firm that we are discussing this morning.

Lord Currie of Marylebone

119. My Lord Chairman, may I turn to the question of the role of the banks. When they do finance start up, to what extent do they get involved in the management of those companies? What sort of effect, good or bad, does that have on research and development spending?

(*Mr Kent*) My Lord Chairman, first of all, it is more or less true to say that the banks are not all that keen on getting into the early stage. They see it as straightforward risk capital involvement which they do not normally regard as appropriate for them. This is not an illegitimate view to take if you are a bank. However, when they do get involved—NatWest has started an initiative which others might now follow—they do help with the structure of business plans. Getting the business plan into a decent shape is part of the kick-off to agree to invest, but I do not believe that they really get involved in the management thereafter because they are terrified of being thought of as shadow directors. This has worried the banks for a long time, not only in this context. It is a serious

Lord Currie of Marylebone *contd.*]

inhibition to them getting involved, and I do not think that they do. Therefore, I do not think that the attitudes of bank managers have a direct influence on the amount of research and development.

120. Is it different in other countries or is it the same?

(*Mr Kent*) I do not think it is different. In Germany they do not really have a hands on relationship in the management of businesses.

Lord Dainton

121. I was very interested in your comments about SMART awards and I could not make up my mind whether you were in favour of them or not—you seem to be in favour of them. Was it just a matter of scale? On page 63 you say, I think, that on the one hand the awards have been successful in levering financial support from banks, but you also said that they were on too small a scale?

(*Mr Kent*) Yes.

122. So what is the next step? Should they be made larger?

(*Mr Kent*) Yes.

123. Have the Department of Trade and Industry been told?

(*Mr Kent*) It is all here ready for them to spring into action! What I think SPUR and SMART have done first of all is help channel the available capital into the winners. It seems definitely to have had a real effect on where the money goes. There is no real evidence that it has enlarged the total of money available so that winning is very crucial to being successful in attracting capital. It does suggest winning provides an advantage. It is a bit like the suggestion that I made earlier that some kind of pre-evaluation before the stage of asking for money helps. If you have a badge or a certificate or a supportive report, you are much more likely to succeed in getting the money. These badging initiatives do work. Some of the earlier evidence quoted in the Report leads you to think that they have been a flop, but by the end you discover that we suddenly think they are actually the best thing since sliced bread. I understand your confusion!

Chairman

124. The Department of Trade and Industry may come to the same conclusion!

(*Mr Piper*) My Lord Chairman, may I just add on that that I think that what we are saying about SMART and SPUR awards, particularly SMART awards, is that they do achieve two things. One is the one that Mr Kent has referred to, that they do act as an attraction for provision of finance, particularly from banks—it is mainly debt finance. The venture capital finances are not so keen to take account of a SMART or a SPUR award. The other important role that they have is actually getting a technology-based small firm to the stage at which the seed capital and the venture capital providers may be interested in helping it. It really gets them across from the position where primarily, as we indicate in the report, funding at the early stage does come from own funds and family and friends; a SMART award can bridge across the gap to where the professional finance providers are more interested.

Lord Dainton

125. Has the scheme been running long enough to enable you to say in respect of the SMART scheme which, to use your own words, is a form of accreditation badge, whether the judgments made there have been good ones or not?

(*Mr Kent*) I do not have an answer, my Lord Chairman.

(*Mr Piper*) My Lord Chairman, I think that Department of Trade and Industry are indeed at present doing some further work that tries to examine the experience of successful companies that have been award winners. We were, I think, impressed by the evidence that came from a survey which was carried out by our own agents, the charts on pages 38 and 39, and particularly the chart on page 39, my Lord Chairman, indicating that in respect of that particular sample of companies around 70 per cent of them had at some stage in their life cycle used a grant of some sort. In the majority of cases those were SMART and SPUR awards. The table on page 38 indicates that in fact those grants have not always been significant at the start up stage; they had sometimes come in somewhat later, but we were impressed by the strength of evidence from that sample by just how important those particular 59 technology companies had found grant assistance, and that was primarily SMART and SPUR.

126. So that SMART and SPUR may be helpful not only in, as it were, start up but also in survival?

(*Mr Piper*) Yes, my Lord Chairman.

Lord Dixon-Smith

127. My Lord Chairman, if I may ask a supplementary question, the graph illustrates the importance numerically of grants; it does not indicate in any way the proportion in volumetric terms, so was the grant significant in financial terms or was it perhaps significant in that it enabled them to have access to other funds because it gave, if you like, a seal of approbation?

(*Mr Kent*) In different parts of the life cycle it can be one or both, but in the long run it is the leveraging effect that really makes the difference. It is the accreditation, the seal of approval. We used the phrase in here somewhere of a virtuous circle and, to some extent, those who have got the approval get the resources and they do survive; and, because they survive, they become the validation for the scheme in the first place. Again we have talked to the successful—almost all the evidence by definition comes from the successful companies—and it does suggest that if you could do more of that quantitatively you would get more success.

Chairman

128. If it is too early to assess the evidence on the individual success relationship, is there evidence so far as to any narrowing effect? You describe it basically as a redistributive process of funds pointing towards particular ventures, but is there a narrowing in the industrial or technological spectrum? Is there a sectoral effect here that you can see, or is there a broadening?

(*Mr Kent*) My Lord Chairman, I can see what you mean, a sort of halo of desert around the success which could arise from that. Finding the people who failed and saying to them, "Why did you fail?" turned out to be very difficult and illusive. We have not succeeded in doing that. There may be lots of people out there who represent the sort of crowding out effect that you suggest, my Lord Chairman. I do not know whether there is any sort of sectoral effect.

(*Mr Piper*) As far as SMART and SPUR are concerned, my Lord Chairman, we do not have any evidence of that. I think that the point that we were more struck by was the fact that these are competitive awards and in some regions it is much more difficult to obtain one of these awards. That is why, in our recommendations, we suggest that there might be a case for looking at the schemes nationally because we understand, for example, that in East Anglia and around Cambridge it may be much more difficult to obtain an award because the competition is stronger. Like others, we have drawn attention to the fact that it would perhaps be useful to be aware of who the "near misses" are who just got squeezed out because, there again, I think that the banks, for example, and other finance providers would find that information of use.

Chairman] You need, like Mastermind, a semi-final of the best losers perhaps!

Lord Dainton

129. I have just one question which is outside your document on the research council Realising Our Potential Awards. Now that they have been running for three or four years and we know that the universities have done well out of them, is this long enough to be able to indicate whether those awards are helpful towards, as stepping stones towards, SMART and SPUR?

(*Mr Kent*) From what I have seen of those—and I also wear a different hat as part of the Technology Foresight steering group—they have certainly made a difference. I think that Technology Foresight of which that is part has had more impact on the universities and the research councils than it has on the industrial side. The effect so far does seem to me to have caused a real sea change in attitude. I have visited some of the research establishments, labs and so on. You can see that there are within them some people rather like those in the American universities ready to seize opportunities. I think that ROPAs have been successful, but I also think that there is quite a long way to go. They could be built on. They are a rather good analogy with SMART and SPUR.

130. Yes, but they do bring us to a point of very acute decision making in the sense that they can, to use the words of those who are advancing science, distort what is a natural development of science and that bodes ill for the future, so how does one get that balance right in the universities? The universities are so strapped for money now that they will go anywhere for it.

(*Mr Kent*) My Lord Chairman, if you look at the White Paper it splits up the Government's support into two kinds, that for core pure science and that for awards. To the extent that these are competing for resources I entirely understand the point that Lord Dainton makes, but in the end I do not know of a better way for Government to try to do two things at once. It is recognising the needs of pure science and has to ration it out in one way or another. There are also questions about how the rationing is done, are there not? There is a dilemma, whether you spread the ration for pure science thinly across all the competing users or whether you focus it on centres of excellence. I do not think within any kind of limited resource environment that you can ever quite avoid that dilemma.

131. It is getting the balance right, you see, and I think that one of the problems that have worried many people recently is the shift of the Office of Science and Technology from its base which was transcending all the departments and putting it in the Department of Trade and Industry which I think many people fear is a change which could shift that balance which in the longer term would be very difficult indeed to live with.

(*Mr Kent*) Yes.

132. Just in the financial returns sense.

(*Mr Kent*) Let me just turn it round, my Lord Chairman. I am not trying to defend that particular formula that we have now or, indeed, to attack it, but one of the things that we talk about in this document is corporate venturing. We have talked to some of the potential venturers, the large companies, like the pharmaceutical companies. At least one of them—mentioned in the Report but not by name—does corporate venturing but it does it all in the United States and not here. One of the reasons, they say, is because they find that the universities in this country are still too reluctant to get their hands dirty on the commercial exploitation of bright ideas. This is due to cultural reasons, anxiety about losing intellectual property, and you can chart why. And so, although the Realising Our Potential Awards have made an impact, the potential partners in that business say that there is a long way to go. That suggests to me that if a real success could be made of the wealth creating opportunities which are within universities, then the benefits of that could accrue back to the universities and to the pure science base.

Lord Dixon-Smith

133. What impact has the European Union Framework Programme topic on the financial environment for the dissemination of technology actually had on encouraging technology funding schemes in the United Kingdom?

(*Mr Kent*) My Lord Chairman, I am not sure that the track record yet is one of great contributional success. It looks bureaucratic and it is hard to access, but it is not just a failure; there are signs of some things. For example, our agent in Liverpool is the chairman of a Fund called the Merseyside Special

Lord Dixon-Smith *contd.*]

Investment Fund with a matching funds approach between the local private sector and in this case, objective 5b resources from the European Union. These are intended particularly to help development in problem areas economically, and there are some signs that it can be done. But it does take a lot of hard work to get it going and a lot of drive from some people who are not themselves the small business creators, i.e. the users.

Chairman

134. That is, of course, the Structural Funds being used there?

(*Mr Kent*) Yes, my Lord Chairman, that is right.

135. As opposed to the Framework Programme.

(*Mr Kent*) The Framework Programme itself I am not sure has made any sort of real big impact.

(*Mr Piper*) My Lord Chairman, we make the point in the report that, under the Third Framework Programme, the United Kingdom did better than any other European Union members in terms of the amount of funding that it accessed in its participation in that scheme. However, I agree with Mr Kent, it is difficult to detect a sizeable impact on the issues that we are talking about this morning coming from EU funding, although again we do mention the ESPRIT programme, for information technology companies, and other EU grants used by a number of the firms that our agents spoke to. Although most of them had had grant assistance, it had been mostly SMART, SPUR and LINK, some of it actually was European Union grant assistance, so there is some effect, but I am not aware that it has been quantified.

Lord Cuckney

136. On institutional funds you have made some interesting and important points about the legal constraints, inertia and the Pensions Act. I found that very helpful and it explained some of the constraints and problems. The large amount illustrated on the chart is probably through investment in funds rather than companies, is it?

(*Mr Kent*) Yes, my Lord Chairman, it is.

137. That leads me on to the one aspect of institutional investment that I think is of great concern and that is exiting. How do you get out? I wondered what your views are on the importance of AIM, any market development which helps you to get out?

(*Mr Kent*) I think that AIM is an important opportunity for exits for venture capitalists and it has yet really to prove itself. As you all know, my Lord Chairman, it really was a successor to the USM which was the junior part of the Stock Exchange. When the Stock Exchange decided to wind that up because they thought that it had merged effectively with the main board, there was quite an outcry which said, "We must have this exit route". AIM was invented to fill that gap. AIM is beginning to be quite successful, but there is more in the wind. There is EASDAQ, which we talk about in the report. EASDAQ is much more like NASDAQ in the United States which provides a network which enables brokers, analysts, small firms, to network because it is done electronically rather than through a single institution. That has not started yet. It is created and it exists, but it starts to operate next year. I think that it ought to make quite a useful contribution. AIM is, frankly, aimed at institutions or businesses which are slightly larger than the area that we have been looking at. If that could come down a bit in size it would start to bridge the gap perhaps between the sorts of size of investment that we have talked about today and the exit opportunity which at the moment is at a rather larger size. As I see it, there is a spectrum from the one man business right up to the multinational corporation. Along the spectrum of financing you get certain gaps as to size or availability or access. It is at the gaps between small and medium, medium and large, that you most frequently get a sort of hiatus.

Lord Currie of Marylebone

138. Does the perception of bankruptcy differ as between the United Kingdom and, for example, the United States and elsewhere and what one can do about that?

(*Mr Kent*) My Lord Chairman, I do not know what one can do about it really. I think that it is true. I do not know anyone who disagrees that there is a different perception. In this country, we are worried about "phoenix companies" where bankruptcy is an excuse to run away from debt and start again. I do not know whether they have that problem in the United States in the same way—I suppose that they do. Should we make bankruptcy more respectable? It is hard to run a campaign on that! Maybe it is partly to do with the way that the courts and bankruptcy law work. Before you get to be a bankrupt or a failure in the United States you can go into chapter 11 and get some protection from creditors. You then have a better chance of working your way through, which is like having a bit of a safety net before you hit rock bottom. The Bank of England has been in favour of something like that for small firms in the United Kingdom. The Department of Trade and Industry had a consultation period on this issue and we said we thought that something along those lines could be a good idea. Maybe there is more that one could do in that direction.

Chairman

139. Then the very last question, Mr Kent, which is, as it were, the problem of success. Are you—and I mean generically the City of London—nicking too much of the best of the output of the undergraduates?

(*Mr Kent*) My Lord Chairman, I thought to be frank that there was something of a *non sequitur* in the question, implying that if they are the best you reduce their status by nicking them.

140. No, but . . .

(*Mr Kent*) Do we do the same with the classicists and the historians and the scholars?—I do not know. Maybe this is a kind of market failure but, if so, it is very hard to know what one could or should do about it. This is a question that has come to us many times. If engineers and scientists are so important to

Chairman *contd.*]

the wealth creating process in the corporate sector, then they are worth their weight in gold—why are they not being paid the gold that they are worth the weight of? I do not know the answer to that, but it may have something to do not so much with the City but with the way in which corporations value the contributions of engineers and scientists. I do observe that in the bad old days of large cycles in economic activity, you could almost predict that the marketeers and the technicians come to the fore on company boards in the boom. Then when the crash comes, the accountants come in and run the company. If you had more stability you might get more balance in corporate boards between the scientists and engineers on the one hand and the finance people on the other.

Lord Dainton

141. One problem, of course, which underlies this at the moment is the steady decline in the proportion of those who are presenting at 'A' levels in science and engineering and therefore also under-applying as it were to university education, so there is a long term problem being stored up here where you will find yourself that they do become critically low in supply. Do you have any observations on that?

(*Mr Kent*) My Lord Chairman, undoubtedly it is true, but to me that is an effect and not a cause. It is an effect of exactly what we have been talking about. If the rewards were better, then we would begin to see people choosing that, I think, as a preferred career path.

142. Then is your answer that the market will automatically raise those career levels, in which case I shall re-study science, of course!

(*Mr Kent*) I do not see why that should not be the case if they are the key to wealth creation.

Chairman] Mr Kent, Mr Piper, thank you very much indeed for your evidence, we are most grateful.

WEDNESDAY 22 JANUARY 1997

Present:

Caldecote, V.
Cuckney, L.
Dixon-Smith, L.
Flowers, L.
Hogg, B. (Chairman)
Kirkwood, L.
Tombs, L.
Winston, L.

Memorandum by Amersham International plc

THE NEED FOR A EUROPEAN SCIENCE PARK

The House of Lords Sub-Committee on Science and Technology is calling for evidence on the Innovation—Exploitation Barrier. The focus of the evidence requested relates to the ability of small firms to act as the medium by which new ideas are transformed into new products and what has been the influence of the DTI's innovation initiatives on these companies.

Amersham can give evidence based on interactions with only a small number of start-up companies. However, it is a company which relies heavily on innovations across a wide spectrum of scientific disciplines and on a global scale. Thus although not specifically addressing the majority of the nine questions posed by the Sub-Committee we believe we should respond to the general question the Committee posed. "To what extent does the United Kingdom suffer from an inability to exploit its own developments in science and technology and what can be done to address this problem?"

At a recent internal seminar at Amersham a leading UK academic quoted a major Korean company investing in Britain. "Coming to Britain is an excellent opportunity for us" he said. "You have good academic institutions and produce excellent ideas. What is wonderful for us is that you do not know what to do with them!" As is well known we are creative but not innovative if the latter is seen as successful exploitation of this creativity.

Within Amersham International we try to highlight this difference by regarding the role of research as the provision of options for future exploitation. The role of development is the commercialisation of our science and technology. Similarly, within the UK the university role should be viewed as a provider of such options. UK companies acquire options of interest and address the commercialisation process, the innovation phase. Because many options fail in the commercialisation phase large companies manage a portfolio of options. Small firms cannot do this, so many fail when the option they have chosen cannot be realised. We believe that this lack of awareness, that in the early stages of "R&D" one is managing options, whereas in the latter stages one is managing the commercialisation process, is a significant contributor to the Innovation—Exploitation barrier. If universities recognised that one of their roles should be to generate options and likewise companies recognised that the management of options is a low cost and low risk strategy, then a major component of the barrier would be removed. UK based companies, as a whole, should see it as an essential part of their role to assist in the generation of the options on which UK Ltd's development portfolio will be based.

The Committee request ideas as to how the problems can be addressed. There are of course no simple solutions on which strategy can be based. However, we would argue that a starting point should be to focus on the "ecology of industrial innovation". The interaction of academia, commercial organisations (large and small), financial institutions and state and local government with each other is the ecology of interest. With the exception of Technology Foresight UK initiatives (DTI in particular) have only focused on components of the issue. The creation of a UK based ecology of innovation will require consideration of some very bold moves indeed. The time has come for the establishment of an entity which recognises that innovation is an integrative activity which requires the active involvement and interaction of all the components of the process—academia, research centres, small and global companies, financial institutions and state and local organisations. We need a European Science Park.

There are about 200 science parks in the European Community. The first science parks in Europe were set up in the UK in the 1950s. The idea was first developed in the United States in the post-World War II years and the primary reason for their establishment in Europe has been the competition between Europe, the United States and Japan in areas of new technologies. During the latter part of the 1980s their number increased by 500 per cent in North America and 800 per cent in the Asia Pacific region.

Michael P Ryan, former President of the International Association of Science Parks has identified four main objectives for these parks:

— to provide a means by which new enterprises are created from the works of academics;

— to create a structure within which technology transfer can take place between universities and industry;

— to provide a means by which academic research is kept in touch with commercial priorities;

— to provide a means by which academics and industrialists generate research and enterprise within their own group.

In addition the International Association of Science Parks defines the term "science park" as:

> "a property based initiative which has formal and operational links with one or more universities, research centres, or other institutes of higher education; which is designed to encourage the formation and growth of knowledge based industries and other organisations normally resident on site; which has a management function actively engaged in the transfer of technology and business skills to tenant organisations."

Although the survival rate of newly created companies located in these parks seems to be higher than the national average for new companies, suggesting that the support structure provides real assistance, the overall impact on the UK innovation quotient is probably still small. We believe this is because the definitions above for the role of the parks are too narrow and focus too tightly on academic—new company interactions. They address only part of the innovation pipe line. We need to establish environments which encompass the total innovation ecology covering the whole scope of local, national and global issues of the commercialisation of science and technology process. The participation of global companies (representing most sectors of the economy) in this initiative is therefore essential. Such companies will only be attracted to participate, however, if they believe that not to do so would exclude them from a major source of future innovation. The proposed European Science Park would have the potential and credibility to gain the involvement of all the essential components mentioned above.

European Science Park: A Vision of UK Innovation for the Third Millennium

Global corporations today account for more than 40 per cent of world GNP. The trend is upwards, a combination of the expansion almost overnight of the world's free market from 1 billion to 5 billion people together with the universal embrace of GATT in terms of world trade. Global corporations have increasingly understood the earnings per share benefit of relocating industrial production to low labour-cost nations. The cost to the maturing industrial economies has been inestimable in terms of social dislocation and the resulting loss of dignity, and the threat to future civil stability.

The political paradox of these changes is that as western governments sense the frustration of their electorates, the old employment remedies no longer work: the Philips curve has disappeared, Keynesian-type injections are under pressure from government deficits enlarged by the burden of social security in an ageing and increasingly unemployed populace. Low inflation, once the panacea as exemplified by the German industrial machine and ordered by the Bundesbank meeting its strictly national remit, now seems to eat at the very core of the "feel-good factor".

Whilst the UK has clearly benefited from its relatively low unit labour cost base within the EU, our current economic crutch will increase our dependence on the omnipotence of the global corporations, progressively weakening the power of the nation-state which still acts as our boundary for democratic representation. Many have diagnosed the misfit between our socialised democracies, competitive deregulation, and the move to a knowledge-based as distinct from an industrial-based society. Fewer have proposed therapies that can effectively be pursued by governments to secure simultaneously our specific national interests together with respect for and reward at the ballot-box.

If we are to maximise the economic value of our nation, we must fully exploit our outstanding national characteristics, brand them and ensure that we capture the attention of the itinerant global corporations. One such characteristic which demands a national strategy is our creativity. Equally we must develop a more cogent strategy to effect the efficient translation of this creativity into successful innovation and global labour rates.

The UK is ideally placed to be the scientific leader in Europe. Apart from independently willed, inventive people, we have outstanding educational institutions, culture, and quality of life, which even today remain internationally highly attractive. Combine with this the fact that English is the international language of science, plus the UK's adequacy in international communications, and we start head and shoulders above our competitors.

Competition for what? World leadership in technological innovation in the third millenium. The answer: to secure the pre-eminent science park in Europe, set in a campus of 6,000 to 10,000 acres in the cultural and intellectual triangle between Oxford, Cambridge and London. A science park marketed at those same global corporations, giving them direct access through partnership to not only the intellectual assets of three of our most internationally famous universities but also a whole range of science and technology based companies and services which will inevitably be drawn to such a park. A science park whose objectives are to embrace the total panoply of scientific disciplines, thereby ensuring a pool of, amongst others, small technology based

companies, skilled technologists and the business and technical infrastructure which will underpin the increasing breadth of science required to achieve a truly effective ecology of technological innovation.

There is no doubt that if we seize the national opportunity, including the arduous process of gaining support from all interested parties, we will succeed in attracting the cream of industrial investment in the research and development and marketing divisions of these global corporations. Only the US has a scheme on such a scale—namely, Research Triangle Park in North Carolina. Neither the French nor the Germans have yet partnered their academic and industrial investments on this scale of integrated activity. The European Science Park will capture for the UK one piece of the national therapy required to secure our prosperity and respond to the realities of global competition, one of the therapies required for democratic success anticipating the changing pattern of world trade in the third millennium. It will provide jobs to underpin our increased focus on education, it will provide enhanced royalty flow to our universities which are increasingly ready to enter industrial partnership. It will provide the pool of intellectual property and skilled scientists and marketeers who will determine the industrial marketing mix and investment flows in the next century.

So much for vision and macro-economics. Why 10,000 acres and why disrupt Middle England? Why—because we need to compete in science just as we do in finance on a global basis. Why 10,000 acres—because this is not a vision for start-up companies piggy-backing on a 100-acre site adjacent to a seat of learning. This is a vision of a campus-based science park, a global corporation planted every 300 acres, each with a science base of 1,000–2,500 people; a park built over a 30–year period and catering for all relevant scientific disciplines; a park that would bring a new meaning to "set-aside"—embracing the goals of sustainability and at the same time underpinning the necessities of successful democratic capitalism.

The third millennium will challenge world society with a new era of world trade and demand new patterns of employment as we evolve from an industrial to a knowledge-based society. We can continue to be masters of our own destiny in the UK, but only if we drive co-ordinated national strategies matching our skills to the needs of the global corporations. We have led the world before, at the start of the 19th century, as the world's industrial power-house. Now at the start of the 21st century we need to lead again.

In science the agenda is clear. We should plan our country's unique assets to ensure our global competitiveness in innovation. Our first step at the start of the millennium must be to plan and construct a science park of such excellence and size that we not only create an environment which vigorously addresses the issue—the innovation of exploitation barrier but also ensures that we become the European nation of choice for the global corporations.

Although the magnitude and scope of this response may seem to be far beyond that requested by the committee we believe that without consideration of the global issues outlined above all other deliberations are merely tinkering at the margins of what is required to demolish the innovation—exploitation barrier. Consideration of this proposal would necessarily have to involve Government, academia, the respective research councils, the DTI and industry (Concept of Partnership). The proposal is bold but then so is the challenge we now face.

January 1997

Examination of witnesses

MR WILLIAM CASTELL, Chief Executive and DR EDWARD LORCH, Scientific Affairs Manager, Amersham International, were called in and examined.

Chairman

143. Good morning, Mr Castell. Thank you for coming to give evidence to our Committee.

(*Mr Castell*) Thank you very much, my Lord Chairman. I would like to introduce Dr Edward Lorch, who has a Ph.D in science, and assists me at Amersham in formulating some of our wider responses, which we see as our industrial responsibility in terms of the enquiring world as to (a) what Amersham does and (b) how the world might adjust its sights to certain topics. I am Chief Executive of Amersham International. It was the first full privatisation in 1982. It is a company that was based on radioactivity. We have two major marketplaces today: one is providing kits and tools to research scientists, both in the pharmaceutical industry and in academia, principally targeted at biological research. We have another principal business sector, which is using our skills in radioactivity, in terms of *in vivo* diagnosis, where we provide chemicals which are tagged with radioactivity, to look at the function of the brain, the function of the heart, and disorders of the liver and the skeleton. The company has sales of approximately £360 million. We are global. We have 1,000 people now in Japan where we have a joint venture. We have 1,000 people in the USA. We have approximately 2,000 people in Europe. Our research and development is limited in its expenditure. We spend approximately 8 per cent of turnover, a small sum by the giant pharmaceutical firms' standards, around £25 million per annum. We make a profit in excess of £50 million per annum. We export a lot of our materials, which are both developed and manufactured in the United Kingdom. There is a net benefit across the United Kingdom exchange of £100 million in terms of surplus on receipts and expenses in currency. What previous experience have I in the world of innovation? My training was as an

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accountant and a marketeer. I became a manager of research and development in 1980 when the Chairman of the Wellcome Group, my previous employer, gave me responsibility for the vaccines business and asked me to make it a biotechnology business. I then moved on to be Commercial Director of Wellcome and left Wellcome in 1990 to become Chief Executive of Amersham. Relevant experience to this Committee's hearing. While I was at Wellcome Biotechnology I started an industrial start-up with the University of British Columbia in Vancouver, where I managed to form a company on the university campus in 1981. I formed a partnership with Genetics Institute, which is the expression of Harvard Molecular Biology, run by the Chairmen of the then biochemistry and the then molecular biology departments. We formed a joint venture between Wellcome and Genetics Institute in Massachusetts in 1984. In my later days with Wellcome I was responsible for its commercial policies world-wide and also jointly for its R&D portfolio. If I turn to Amersham. I moved to Amersham with it in mind to develop the marketplace of molecular medicine, drawing considerably from the strengths that we have in the United Kingdom, in terms of applied molecular biology and from the vision of Professor Weatherall, Regius Professor in Biochemistry at Oxford, who in 1982 exposed the world to the implications of understanding, at the molecular level, what it could do for both health care and for industry at large. We have focused on health care. If you look at partnerships we have today, we have focused for example on one area, DNA sequencing. We have a partnership with Hitachi, a partnership in Japan, and a partnership in Silicon Valley with a company called Molecular Dynamics. We also work in partnership with Oxford University. A key part of our industrial portfolio is enzymes; specific enzymes are used in the sequencing of the gene. There we benefit from exclusive relationships with Harvard University and with the University of Berkeley, California. A key part of our industrial intellectual property bag is the world of fluorescence. There we have an exclusive relationship with the University of Pittsburgh. The overall world of molecular biology is vitally important to us and we have, for a long time, been principal supporters of molecular biology at Cambridge. We have strong partnerships with the University of Cambridge and, in particular, the Laboratory of Molecular Biology. You will see from where I am coming from; that the emphasis of innovation and partnership will come through time and time again. If I reflect on our success, no matter how small it has been in *in vivo* diagnosis around the world, then our brain scanning, which is unique and allows one to look at the function of the brain, came from a partnership with the University of Missouri. Our heart scanning agent, which allows one to look at the function of the heart and the viability of the heart, involved funded research at the University of Cardiff. An agent we have for the relief of bone pain involved early collaboration with the University of Southampton. We are a small company who cannot afford to have a research establishment at the cutting edge of the relevant sciences to our business. We can only develop and be successful in innovation if we partner around the world with those people at the cutting edge of science. The reason why I believe this is relevant to this Committee's deliberations is that this trend, which is appropriate to my company with an R&D spend of only some £25 million, is increasingly relevant to the major pharmaceutical companies who find that they are no longer able—because of the nature in which innovation is now developed, or how the research options are now developed—to come up with the research options. Increasingly they are looking at their partnership relationships for the research option, which they take through to innovation through the trained management processes of development, risk taking, and later marketing. What I would like to do briefly is to look at the rules that I see applying to Amersham that allows us successfully to innovate, and what the rules are which would be taken to apply to United Kingdom Limited in which I have a particular and passionate interest. This is because although we are global in our operations, we are intensely nationalistic in the pride with which we develop our business. The success to innovation for Amersham. First, we have to nurture a culture of innovation which in an intensely conservative society such as the United Kingdom remains, means that we have to encourage and reward risk-taking as opposed to intellectual observation. We have to nurture research relationships. You cannot ask a scientist to conform. If you find a brilliant scientist you give him the background to work within which he feels comfortable, so the nurturing of research is vital. Development can be very much a disciplined business, but research nurturing is a different exercise. As a company we have to be at the cutting edge of science. We have principal research locations in Amersham and in Cardiff, but we need to be aware of what is happening in the world of science to ensure that the decisions we are making are made against the background of competitive world science and not what we happen to think is competitive within our own laboratories. Increasingly I believe this applies broadly across other industrial structures. For innovation to be successful you have to fuse many more technologies than was hitherto the case. This means that the real talent in innovation is the scientist, who has the general skills to look across many function areas of science and blend them into a product. If I look at what we are doing in instrumentation to sequence genes we are bringing together pronounced thermodynamic skills, IT skills, electron-microscopy, enzymes, fluidics skills, a plethora of sciences which you would not find in any one company but that is necessary to bring about innovation. We also need to have a flexible attitude because for us, at least, innovation means working the worldwide network; so our science teams work across from Japan, through Cleveland, through California, through Cardiff, and through Amersham. Therefore, communications and teams are vital and for that we need not only a familiarity and acceptance of linking with videos and IT, but I still put extremely heavy emphasis on relationships; relationships of trust and understanding which come only because of personal contact and it cannot all be remote work. Above all else, I believe that scientists today respond to civilised communities, or their perception of civilised communities. When I say this

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I think you can see increasing clustering in the world of science, where people are thinking about where to lay down their R&D in the future, where they cluster their ideas. Silicon Valley occurred for one particular reason; probably more because of the hedonistic attitudes of California, combined with the defence expenditure of the United States Government. But if you look at later developments in terms of successful technology areas, then one has to look carefully at what was the mechanism which made Massachusetts successful; that made La Jolla San Diego successful. Increasingly, when I talk to my colleagues in the world of the pharmaceutical industry, I see a clustering between Philadelphia and Massachusetts, a clustering in California, and a clustering which is willing to contemplate around London first, Paris second, and Heidelburg third. They are the shortlist of three that I see appearing on people's agendas, as I enquire with them where they would best lay down their next research and development capability. We have an access to science in Amersham which is rare. We transfer technology to the top 36 pharmaceutical firms around the world, whether they are in the United Kingdom, Europe, USA, or Japan. That allows us to have an interchange with the management of R&D to discuss not only their programmes, but also their philosophy of science and where they see science taking them. I do believe that innovation is more and more (using a hackneyed expression) a global village. I believe that is a trend which will continue as far as the major corporations are concerned. What do I think is the right background for the ecology of innovation and how does that suit what we have in the United Kingdom? We have undoubted national assets which we have, to date, unsuccessfully exploited. We are a creative and free world people. We are not a consensus society, such as Japan, who had consensus because of survival and who have not been particularly successful in developing research options, but who have been immensely successful in planning successful innovation. English is now the international language of science. When I was a student I was not sure whether I should be learning German. Fortunately, as I am an appalling linguist, I came up trumps and English is the international language as far as I am concerned. We have, in the United Kingdom, internationally respected academic establishments. Those establishments are vital if one is to succeed in the clustering effect, which exemplifies those exemplars of successful high-tech communities today. We have, in the United Kingdom, a civilised way of life. The scientist does not always use what we might describe as the civilised facets of a community but he always demands, in my experience, that he goes there. I think I draw from the banking community the fact that we have demonstrated that we can have the centre of European finance in the United Kingdom, which speaks well for what we could do for science if we targeted the policies of science. We have world-class communications, not only physical but also electronic, and to be part of the global hub in aircraft communication terms is, I believe, a vital part of at least being part of the global society in terms of global corporations, not necessarily a part of the global society in terms of start-ups. I would like to say there are two reasons why we have failed. We are not good at partnership. There is a national reticence to a successful business or a successful individual that certainly does not occur in the United States of America. Since the individual does not stand in Japan, it is the organisation, that particular attribute does not get in the way of the consensus society within Japan. I see a partnership between academia, business, government, and the financial communities as being an essential ingredient, whether we are looking at the start-up industry or a success in attracting and maintaining global corporation investment in the United Kingdom. How might we succeed? The first thing I would stress is that I do not think we should copy previously successful solutions. Those solutions have been against a different background; a different background of evolution of technology, of cultures and societies. Today this is more so than 20 years ago when research travelled and when we set up a partnership in North Carolina which was immensely successful in the then environment, but we were much more of an industrial society then, we are today a knowledge-based society. However, I do think that if we are going to succeed, then I hope we can evolve a policy which will deal with the faceless global organisations. If you have read my note, you will understand my sincere desire to see that we find the ability to relate democracy to wealth creation. We need to do that through our science base and targeting those who determine jobs; and targeting those, such as the global corporations, to come here; not just because of the competitive employment rate within Europe, but to come here because of the quality not only of the research options for which we are respected, but to be given the opportunity to work with that research option and draw from a pool of talented labour that can allow us to build an innovative network in the United Kingdom. My experience is not in the high-tech start-ups, although I was very much in the start-up industry of biotechnology in the 1980s, and feel I have been a part of that and witnessed that for nearly 20 years. My attitudes and directions both are more to looking at how we build a clustering effect—not how we support the inventor with his option—but how we build the cluster. That means that the innovative machine is there and working alongside the inventor to take his research option through to innovation. I have been working over the last year and a half to try and mature these ideas. The thing I report with considerable delight to the Committee is the access I have now gained to Oxford, Cambridge and London, to discuss these concepts with the heads of colleges and with the chairs of the relevant sciences and disciplines, and to find a willingness to engage in this type of discussion which I know was certainly not there in the 1980s when I undertook a similar exercise. I have also discussed with local government the issues of how one moves from green belts in areas of outstanding natural beauty to areas where government brings its contribution, for which, if one undertakes such a bold policy, you have to have a planned infrastructure. You have to deal with the houses, the education, the schools and the road networks. If industry can see that government will take it through the Newbury Bypass syndrome, which hopefully would not occur in this case, then

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you will find the way to come. I can name you five important companies today, with whom I have discussed this, and who have said, "We would very much like to come to the United Kingdom with our next major investment. Of our European investments we see the United Kingdom as being the premier base within health care to make such an investment."

144. You have touched on a number of what you see are the strengths and weaknesses of the United Kingdom, and its ability to move from what you describe as option management to commercialisation. If I asked you very briefly to sum up what you saw, let us say, as the three main barriers to the successful transition, successful crossing of the divide between the issues you have just outlined to us (that we can hope to have some impact on in the relatively short term), could you give us your shortlist of three?

(*Mr Castell*) Yes. I would say there were three, my Lord Chairman. The main barriers have first been cultural, where I feel there has been an improvement. But that willingness to set aside—I use the word set-aside, I am appalled by set-aside—I say we have moved from an agrarian society, yet our planning laws are wholly cultural within the United Kingdom and bravely protect our wonderful inheritance, but which are not necessarily compromising enough to make sure that we have competitive employment for the future. I would see the massive task in moving the culture of society to understanding a national strategy that could deliver wealth, security, community, and civilisation in the next millennium. I think moving the culture is the biggest challenge. This is not something I find a problem in North America. When in the 1980s I was looking for the opportunity of starting a massive joint venture with the Genetics Institute in Massachusetts and Rhode Island, I found that the state governors came out to say, "Please build here." The local communities came out to say, "Please build here." It was not that the financial incentives were necessary, but that they had got rid of all the blocks. In the University of British Columbia in 1981, the Chairman of the Medical Faculty moved out of his office and allowed me to take half of his medical faculty to build a commercial institute in the centre of the campus. I found his personal sacrifice outstanding. So I have to say that the number one block is that there are so many pieces of a community that have to come together to encourage a positive strategy—I am not going to say progressive—but a positive strategy to wealth creation, and that culture is one of the facets that government has to deliver because it is a combination that we all have to create the right culture. Number two is infrastructure. What is necessary is an infrastructure plan which allows one to understand not only that there is civilisation there today, but it will be there tomorrow as one expands a campus or a clustering of technical innovation. If you look, as I have, at the planning guidelines around the particular areas I am interested in, I am already finding a frustration in terms of what is going to be permissible in terms of new housing development. New roads: I can already see the limits being met because I have looked at the guidelines in Oxfordshire and Buckinghamshire, etcetera. Infrastructure has to be led by government, national and local. I think the last thing I would say, my Lord Chairman, is that a targeted approach would be necessary. So is targeted partnership. I have found to my delight politicians, academics, local government and industrialists, who are prepared to work in partnership. But I think partnerships need to be not loosely created but formally crafted for a strategy of a clustered approach to technology, which is one I am totally committed to, were it to be successful.

Lord Flowers

145. Many of the concepts and many of the practices you described in your very interesting introduction were, if you like, an echo of what Ian Harvey of BTG might have said. Do you have a partnership with them?

(*Mr Castell*) We have a licence and I know Ian Harvey. I have known him for 15 years. We have several licences on some of their top technologies. We do not have an intellectual partnership. We have a relationship in terms of licensing key parts of British innovation.

146. I am talking about a much wider partnership. You were talking about partnership a great deal. I would have thought you would have wanted to forge a partnership with somebody who shares your ideas and practices so closely. It is an opportunity not to be missed, I would have thought.

(*Mr Castell*) BTG might have a similar vision. I have not discussed it with them. Thank you for the introduction. I will visit with them to do that. BTG has a package of intellectual property and introductions to universities, and is doing an excellent job in stimulating universities. I have had several discussions of late with Cambridge colleges, trying to get them to understand innovation, and how I feel they should develop their patenting. I am going there to form academic partnerships. Our scientists are working with their scientists. Our scientists go to their laboratories and advise and vice versa, so that type of partnership is also a vital one.

Lord Dixon-Smith

147. How effective is the support for innovation in Japan and the USA? Are there lessons which you have learned from that? I am never sure whether the effectiveness of support is due to the effectiveness of the recipient rather than the effectiveness of the donor.

(*Mr Castell*) Japan is very poor at developing research options and has historically been very good at delivering innovation. They are excellent planners. The unique thing about Japan—and I have been working very closely with Japan for 18 years—is that once they adopt a development programme, because they build consensus within the company to adopt it, then everything happens. It is uniquely co-ordinated. Whereas we tend to take a development programme to a board of directors who say, "Yes, we agree that," and then we start to put the organisation in place which dictates it through the company. Since they are still driven—at least my age group is still driven—by survival and their consensus society, they have ironed

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out the ability of original thought, in my experience. Therefore, Japan is excellent at innovation but very poor at developing research options. They have tried to develop research options. Tskuba is a failure. It is outside of Tokyo. They have shipped the government offices down there. They have tried to make it a business city. It does not have the perception of being a good place to live. People travel back to Tokyo. More importantly, it is not a clustering. It is uniquely isolated. There is no academic unit in Tskuba. So Tskuba, I believe—I hope the Japanese will not be offended by this—but I do not feel that they have had the success they were seeking. I would also say that you see the Japanese government announcing enormous sums of money to encourage research, and at the moment they feel as if they are a mature industrial society having lost their way. The changes in Japanese psychology are quite enormous at the moment I find, and I go there frequently. So they are excellent at innovation but poor at creating research options. I do not believe that they have demonstrated successful planning or bringing research and innovation together. They are increasingly looking overseas and they come to the United Kingdom a great deal to see whether they can find research options which they know very well they can develop as supreme marketeers. The USA, I would say, was a different environment. Research Triangle Park was certainly an engineered environment in North Carolina, where the state fathers wisely saw that if they put within the triangle three universities in a research grouping, and brought in mixed skills, chemistry, engineering, IT, and pharmaceuticals, that they could create wealth in North Carolina. They did that very successfully. But having created a mechanism you saw the other parts that were necessary, the airline hubs, the infrastructure. That came in latterly. However, they did well with Research Triangle Park, which was a successful planned development. I believe in the Massachusetts corridor that what you saw was a natural clustering around academic units which left their doors open. I am not deeply involved in how Massachusetts' success overall came about, but I was in Harvard in 1980. I have continued to go to Harvard and have watched how that society is changing, how the interface is changing, and how the corridor has withstood the recession in the IT industry and has come back again; so it is an immensely successful part of the USA. If it is helpful to you, I would say that this was not a planned environment, but it reflects the culture of North America

148. You have mentioned the need in developing commercial success for a combination of scientific disciplines and I fully appreciate that. The one thing you have not mentioned so far (which perhaps you would not because you do it instinctively and you would use yourself) is management skills; but to pull this lot together and persuade these diverse people, many of whom have idiosyncratic ideas about the way things should go on, does require a discipline which is certainly not scientific.

(*Mr Castell*) I mentioned technology fusion but you are right, the management skills of nurturing the egos and blending the disciplines of research and development and bringing together the various interested parties, are unusual skills to find in individuals. I had the privilege of working in Wellcome for 20 years. I was given various exercises in every part of the world, which allowed me to start to understand some of the cultural distinctions which you find in the global community. I worked very closely with the Russian Academy of Science; I worked closely with the Chinese; I worked closely with the Japanese and with the Americans; and I worked with the bureaucracy and industry in each of those geographical locations. I have not found it a problem to identify the common interest. Building consensus is not usually a problem but building the management capability that delivers consensus, I believe, is a real challenge. I remember very well being involved in the very early days of Canary Wharf. We brought together, after years of looking at barren docklands, a number of interested parties. We had more bricks and mortar successes than failures, but I do believe that at the end of day we will have success; so we have demonstrated even in the United Kingdom that we can bring together those interests. However, I do not think we should always believe that we are going to be 100 per cent successful when we pursue such a vision.

Viscount Caldecote

149. It used to be said as far as Japan was concerned that MITI was a very great influence on finding government finance in the early days of high-risk development. One of their great skills was providing the money and then letting the company develop and use the money from them for the early days; then stopping the resources and letting them get on with the job which they had helped to start, and then using the money elsewhere. Do you think that is still an element?

(*Mr Castell*) I tried very hard to discover in the 1980s what the effect was of MITI and Keidanren on the success of Japan. I found it very difficult (and still do) to find Japanese industrialists who will admit that there is a very close relationship there. However, what I do feel happens in Japan is that a national policy is decided with the major corporations who still have a Zaibatsu feel about them, and they still pursue that policy. So I think there is a division of focus that is achieved between government and industry, and industry then pursues broadly the allocated focus they have been asked to look at. I do believe that MITI's influence today, from where I sit, is considerably less than what it was in the 1980s. I believe the globalisation of Japanese industry, as Japan in the early 1980s saw themselves with a problem which was over-employment; they moved a lot of jobs out of Japan to keep the high-tech jobs in Japan and employ more routine skills at lower labour rates overseas. We have now actually seen Japan slightly put aside as a result of the so-called bubble and the psychology of success in Japan we are now questioning; so I am not sure that there is the clear leadership that there was in the 1980s. But you are certainly right. Large sums of money were directed by MITI. How those were received, and whether any more would acknowledge that the financial support was there I could never get that confirmation, but I

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did get the confirmation that people were directed specifically to areas of focus in terms of technology and marketing to develop their international base.

Lord Winston

150. It is a pleasure to see you here today. I have been using Amersham's kits for a long time with the Post Graduate Medical School. I do not know whether it is innovative of you, but you have recruited one or two of our senior staff in the past!

(*Mr Castell*) Good!

151. I would just like to ask you about the health care sector. With the information technology industry in California, which has been a virtuous circle of small companies being successful in similar fields, we are wondering to what extent this is now occurring in biotechnology and the pharmaceutical sector in Britain?

(*Mr Castell*) The virtuous circle: I completely agree with that concept. I found working in Palo Alto in California a remarkable industrial experience, when you see the skills base that you can call on in terms of innovation. You will work from a much smaller threshold of people and skills than you could do in northern Europe because of the support industry which is there. It is a very exciting environment to work within; exciting in terms of the speed of delivery and the reduced risk that one has to take. For example, you sit with the chairman of your company in California and he says, "I am going to move premises over the weekend. I am in 30,000 square feet at the moment but I need 70,000 square feet," to which you say, "How long is your lease?" He says six months renewable and not 20 years. I feel that is a vital factor in terms of flexibility of industry. Within the United Kingdom I do believe that we are starting to see the development of a small biotechnology industry, where it is increasingly accepted. We increasingly see the financial market saying that because of the spread of investment in this sector, you should take the risk and invest in it. So we are seeing a development from a very small base which certainly should be encouraged. It has an *ad hocism* to it which at times worries me because if I take the pharmaceutical sector, to go from a research concept to the globalising of that product, the minimum you need is 5,000 people out there, and a skills base and an investment base which are enormous. I think the way to increase the success factor for the high-tech sector is to encourage this relationship between the research concept, the initial innovator, and the global player who takes the concept to the global marketplace. Otherwise these biotechnology firms will spend all their life in the air, learning about the different distribution mechanisms in Europe, Japan and North America, and investing their time in unskilled players in areas where there are already professionals at play. So to see this environment develop as we are starting to see in North America, more and more of these start-up groups are working with major pharmaceutical firms to see their concepts go to successful innovation. I think you can name Genentech and Amgen. Unless you are going to correct me, they are probably the only two vertically integrated companies worldwide. Then Genentech was acquired by Roche and Amgen is still independent. These are incredibly important vehicles. I think we need to encourage the culture, that understands that to invest a skills base in trying to develop a new product, which requires globalisation in a highly motivated industry, is immensely difficult.

152. Just very briefly, would you like to say what the main difficulties are for companies for start-up in the health care sector in this country? Also, we would be interested to hear what support is available for access to the big markets in the States and in Japan.

(*Mr Castell*) I feel that whereas I have been very free with my advice I have covered so far, I am somewhat limited in my answer in terms of what limits the start-ups in the United Kingdom.

153. You mentioned, for example, the companies that were thinking of coming to the United Kingdom that you had been talking to.

(*Mr Castell*) But the ones I was referring to are people who would establish an investment base of between 500 to 1,000 to 2,000 people. These would be their trained innovative teams, who would come to work here alongside the universities, to draw both research options technology as well as science from those universities. I think we do have a major issue in terms of the problem of start-up which is: where do you intend to take your start-up? If you take your start-up to say, "I am going to be a fully fledged pharmaceutical company," that is a very tall order and will require towards 15 to 20 years of your shareholders continuing to reinvest in your company while you establish sales forces in the USA, which cannot be less than 150 people, and in Japan where they really cannot be less than 200 to 250 people. So conceptually I would say to you that one of the problems of start-ups is for the start-ups to understand what is their relevant role. The thing we are missing in the United Kingdom, which is now available in the USA, are trained managers who come in and sit alongside the scientist and say, "We know how to deliver for you the wealth creation, which will take you to the next step. We will get you through the first regulatory hurdles, the first clinical trial testing, and then we will work with you to introduce you to major pharmaceutical firms, to take you through to the further stage which is the global marketing of your concept." To answer your question specifically, you do find in the United Kingdom the environment which was there early in the United States, which is the excited scientist who has a great vision and who feels he can take that vision all the way through to the marketplace. That is very dangerous ground because he may be a great scientist, but he is likely to be a poor manager, and is very unlikely to have any concept of how much he has got to go through in funding capital, etcetera, to get in there. What they now have in the USA are people who are venture capitalists, who have made a great deal of money in supporting the start-up through the initial stage, and have become professionals in delivering those mechanisms to the start-up companies.

Lord Tombs

154. Mr Castell, you made an interesting comment about the role of universities as developers of options. That is the way universities would see what they do. The problem is how they take themselves to the next stage of implementation. Not all the large companies take them up because they have the inertia of their own R&D departments, and small companies are baffled at the sheer dispersal of knowledge by the large number of universities around the world. I wonder if you could tell us how you would solve that dispersal problem; how you would tackle that in Amersham. You have set up a number of university collaborations around the world. Did they arise from your approach or from the universities selling their ideas to you? Where do you see your role going? Do you see a further concentration or less?

(*Mr Castell*) We have targeted the area of innovation in which we wish to be in. We set up listening posts in Japan and the USA to tell us where we might go. We listened and then went to the places where we felt were appropriate for that research collaboration. On our advisory board, which meets for a full six days a year, we have the Chairman of Molecular Biology from Harvard, from Stamford, Head of Sloan Kettering Clinical Research, the Max Planck Institute, and Oxford; so we use that network to tell us where to go. We then go and form a collaboration. We tend to go to senior level initially, so one of my colleague directors, or myself, go in to see whether we feel there is a climate for collaboration. So far we have been successful in the areas we have targeted in forming that collaboration.

155. So you are saying initially that it comes from you and not from the providers?

(*Mr Castell*) The initiatives have come from us, but being very well advised by academia as to where we should go, and being underwritten by our friends in academia to their colleagues in academia as being the people who would be respectable partners and deliver their part of the bargain. So there is a reputation element in that as well. I have discussed with the heads of colleges at both Oxford and Cambridge how they see the mechanism working. They have said to me that they would be very willing to open their doors to the industrialists that arrived. They would be willing to settle a mechanism to see whether there was an area of common interest; and they would see their heads of department pursuing that at least at that stage. So I found a very good environment where a mechanism of interchange could be facilitated, but it would have to be carefully worked because no-one wants to waste their time with relationships that even if they were developed, would be of no substance afterwards. There is a refereeing process going on, which opens the door in the first place.

156. I think the snag with the refereeing process is that a lot of work goes on which is not published yet, so your entry doors are not open. One way of solving that problem is to have one or two chosen vehicles and establish close links with them, so that you establish your partners with them early on. You get to know their way of thinking long before their publishing what their ideas are.

(*Mr Castell*) I absolutely agree. Whether we are in engineering, electronics, chemicals or pharmaceuticals, across the colleges there is a skills base where this can work. I encourage my colleagues, whenever possible, to visit the colleges and dine with them. I dine at various college whenever I can to meet the researchers to explore ideas. If we can find a mechanism for creating informal interfaces, then that is the mechanism which should be identified. This is because it is the informal interface which is far superior, but the door has to be opened in the first place.

Lord Flowers

157. You have talked about the need to integrate the various components of the innovative process and, of course, I agree. You also talk about the fact that industry is going global and global industries tend to be the more important, in a sense, and I agree with that too. You then make a rather daring leap from that and say, "Let there be a European Science Park," but it does not follow at all. I would ask you what the argument is that leads from one to another, because the suggestion of a European Science Park is an important one, whether it is right or not. Our experience of science parks hitherto has been of something led by a single university, which invites in firms of a kind that it thinks will flourish well in the environment that is provided. There is only one exception to this that I know of and that is the Research Triangle in North Carolina. All the others are led by one university, not by a group of universities, certainly not by a European network of universities if that is what you are suggesting. I am not clear what the arguments are which have led you from your starting point, which I happily agree with, to the proposal of a European Science Park.

(*Mr Castell*) I certainly agree with you about Research Triangle and I researched extensively with Research Triangle in the 1980s. I started trying to formulate a vision for how we might deal with United Kingdom Limited about a year and a half ago, and I was drawing heavily from my past experience. As I have read more closely, I think that the experience probably of Massachusetts, where you see clusters come in, is probably more important than the word "science park" which for most people, because of the scale, has not been a successful operation. In my paper I referred to the fact that I felt we should link Oxford, Cambridge and London. That comes back to branding. If you say to someone in Korea, "We would like you to come to work in the Oxbridge/London triangle," they know where that is.

158. Forgive me for interrupting but Cambridge is doing very well, thank you very much, and it is very much tied up with the global corporations.

(*Mr Castell*) I think it comes back to scale. I am extremely keen that we see 50 global corporations in the year 2030 invested heavily in the United Kingdom. I initially suggested a science park which might be as large as 20,000 acres. That was bearing down from the experience of Research Triangle Park. Also, I was trying to wager with myself the very different environment that I find in La Jolla, where people are cheek by jowl, and saying: what is really necessary in a country which has limited resources? The scale of operation, however we should target, is

Lord Flowers *contd.*]

for a great number of multi-nationals, whether they be in engineering, the motor industry, the aerospace industry, the IT industry or chemical industry. We should target clusters of high-technology, rather like that found today in California, which gives you a self-supporting environment. A science park of 100 acres, no matter how cramped you put in people, would not accommodate what I feel we should do as a nation which would say: how do we cater for the global corporations? So it is the scale of operation. The other reason for saying about the European Science Park is that we are competing within Europe. The global corporation would say, "Where do we invest in Europe?" We have seen the banks come. We have seen the manufacturing come. What I would like to do now is to see the R&D come. I think initially the cluster has to be rather like Research Triangle Park across a number of universities, because no one university is likely to have the capacity to support either the training need, or the research option need, or the technology need of such an industrial conurbation. The attraction of Oxford and Cambridge and London is that they are branded. They are of the size and substance which is now world-wide. They are close to communications. Do not try and put in Strathclyde because I do not believe the president of a well-known Korean corporation will come here and take two further planes to get up to see his research campus. Communications is a vital part of this. I use the word European science park; if I was in the fashion of the technology, I think I would talk about a Technopole probably and talk about the need for government not to plan on one industrial sector or one particular company but plan to create the support environment that would allow large corporations, which themselves would draw smaller companies and start-ups with them into an industrial network.

159. Who would manage this enormous enterprise? Universities find it difficult enough to run a few hundred acres on their premises.

(*Mr Castell*) I looked at development corporations and said: "Do we have to go that route or could we go a plc route"? I have searched for the land throughout what I have described as the triangle but I have a particular interest in and I find it inordinately difficult to cluster more than six or seven thousand acres and I find it extremely difficult therefore to see that the plc route if necessary would be viable. I think it has to be a Government initiative in terms of infrastructure. I think it has to be an agency in terms of partnership and you are asking me to go a stage further—and I am ad libbing now, your Lordship, this is not planned—I think what we have seen in terms of how we developed London Docklands that you could have an agency, a development corporation that could be established to target such an operation and it would seek to create partnerships but it would never be a principal.

Lord Kirkwood

160. I must say I find your vision of the European Technopole a very exciting one. One of the things I would question, nevertheless, is siting it in the triangle between Oxford, Cambridge and London which may be appropriate for health care but I am not quite sure that engineering manufacturing would feel comfortable in that position. This might lead to the second part of the question whether in fact a Technopole or park should be specialised or more broadly based? Can I ask another question: one of the barriers of exploitation, of course, as you have pointed out, is communication between the various partners in the enterprise. Placing a collection of disparate research and development establishments of various global companies on to one site of course does not ensure that there is the right sort of interaction between them. How do you foresee the proper sort of interaction coming about? I say that because the culture of industry tends to be secretive, that is my impression anyway, coming from the university culture where it is all terribly open. In fact, one of the things we are always condemned for is we give other people's secrets away but the culture clearly of most industries is to be very secretive about what they are doing. How do you overcome these barriers in such a situation?

(*Mr Castell*) I do not believe that you can enforce a culture of trust and integrity and community between any two parties, that is something they have to explore for themselves. I think this comes back to the idea of clustering, that you cannot design totally what skills you want in that Technopole and you cannot design totally what the communication base will be but you can establish the saplings of a structure that will evolve its own dynamics. I hope I am answering your question, in saying that it is the saplings we have to concentrate on, once we have the saplings in place the dynamics will occur. International communication is vital but in planning innovation in old style pharmaceuticals I used to look very much at spatial relationships. I knew if pharmacology and clinical and toxicology did not talk to one another, I had an unsuccessful organisation. I could not make them talk to one another but I planned where they sat, how they got to the canteen and made sure that through sports and other events they met one another. I think I would say that one can plan for, within a company or within an area, the types of mechanisms that allow relationships and contacts to be made; you cannot enforce them.

161. It is dreadfully important though, is it not, in order to make them successful that the social activities provide interaction?

(*Mr Castell*) Vital, but may I take a specific example? We supported from the start the Oxford Innovation Society. We became a funder of that, we go regularly to the dinners, that has spilled out many contacts across Oxford which were not previously there. That is an ideal mechanism of achieving an interface which was not possible previously.

Viscount Caldecote

162. You implied in your opening remarks that over your very wide field you would like to spend more on what I would call development, new product development. What are the limitations on the amount that you feel you can spend? Are they financial in the sense that if you spend too much you

Viscount Caldecote *contd.*]

reduce your profits and the financial people do not like it or is it skill limited?

(*Mr Castell*) Principally financial in that for continuing support in the financial markets we need to demonstrate a reasonable increase of profitability. Since certainly I regard R&D as an appropriation of profit we have to have the balance between how much we invest for the medium and long term and how much is reported and available to the shareholders in the short term. It is that balance certainly in my experience which is the key balance but they are two very different sizes of business I am talking about.

Lord Winston

163. I am very intrigued by your notion of a European science park which is a very interesting idea. Can such a geographical conglomeration to some extent be replaced by a virtual conglomeration because, of course, buildings which are together but separated do not make for that easy communication. People do not cross geographical boundaries very easily, certainly in academia they do not.

(*Mr Castell*) In our experience we need the virtual relationship as well as the personal relationship. In partnerships I think that unless you strike a personal relationship then the problems that any partnership will meet will endure, you will not evolve through them. If you work a business partnership on a virtual relationship, my response is you will find the ability to deliver the vision much restricted because you have not formed that personal bond and that is my business experience.

Chairman

164. Can I thank you and your colleague very much for coming and sharing your knowledge with the Committee.

(*Mr Castell*) Thank you for the opportunity, it is something I feel quite passionate about. I can report to you that I have discussed this with Japanese, with Americans, influential in my particular sector and with governments around the world and I find a willingness for people to lend their skills base and their support to such an initiative. Certainly it is not something which is a unique concept but I do find a willingness to see this type of scheme be developed. Thank you for your time at the Committee. Anything that facilitates the United Kingdom being pre-eminent in innovation in the next century I will applaud totally.

Memorandum by Dr John Forrest

There is a strong culture of innovation in Britain; the weakness lies in a lack of understanding or experience in how to develop innovative concepts into wealth creation. This must be tackled first in the schools and universities with the objective of giving students the ability to write business plans and to assess risk. The role of retired business people and "business angels" here could be significant since, in general, the school and university teachers do not have the required experience.

The UK has a well funded structure for providing "development capital" as opposed to "venture capital". Development capital meets the needs of small firms that are already trading successfully and require sums in excess of several million pounds for acquisitions or expansion. There is, however, difficulty where smaller sums are required or where the company is a start-up and trading has not yet commenced. This "venture capital" is in shorter supply, because of the higher associated risks.

Unless start-ups can identify fund-providing "patrons", they may be led into situations of borrowing from the banks, which can be hazardous when cash-flow becomes tight, as it may in the early stages. Bank loans have an important role to play in innovation, but there needs to be a safety net to assist companies through short periods of difficulty.

Again stemming from weaknesses in the education system, there is frequently a major communication barrier between innovators and investors. The investors mostly have little understanding of science and technology; the innovators have poor abilities in communicating the features of their innovation and setting it in a business context that makes it an attractive investment. There is a role here also for those with business experience to improve this communication process.

The DTI has done a very good job assisting small firms with contacts, advice and information. While it provides a certain amount of funding and this is helpful, the DTI role should not be to replace the investment market.

There is now an understanding in the European Commission about the desirability of achieving a venture capital environment similar to that in the USA (EC Action Plan for Innovation, 20 Nov 96). In the 5th Framework Programme there is also the intention to focus effort on providing linkages into venture capital funding. To be successful, this will require substantial change in operating procedures in an organisation such as the EC which has traditionally been highly bureaucratic.

Examination of witness

DR JOHN FORREST, Chairman, Brewton Group plc, was called in and examined.

Chairman

165. Dr Forrest, thank you very much for coming to give evidence to this Committee.

(*Dr Forrest*) I think I have been very fortunate in my career so far in that I have had phases in the university world involving teaching and building up research activities, then in industry and then the fascinating experience of taking an organisation from the public sector into the private sector and growing it as a very exciting business. My activities now are really very much focused as a Chairman or non executive director on a series of companies for which the common theme really is information technology and digital technology. These companies range from sizes where the turnover is somewhat in excess of £100 million per annum right through to very recent start-ups where I have joined both as an investor and a director in situations, I am glad to say, very akin to Silicon Valley in the USA. The areas that you are considering are of very special interest to me.

166. If I was to start by asking you to give us a short list, let us say three maybe, of what you see as the most important barriers between research ideas and their exploitation in this country on which we could hope to have some impact in the short to medium term, what would you identify?

A. My Lord Chairman, I think I would list two rather important ones and then another which is culturally much more difficult to tackle. The first I think I would give is the communication process between innovators or inventors and the investors. The innovators that I have come across are frequently rather poor at communicating the commercial potential of their ideas. Very often they are tremendously enthusiastic, very well versed in the technology but they find it very difficult to get across the commercial and market aspects. I think that goes back really to a topic which I hope we will touch on later which is the education system because I think the problem starts in the schools and does continue in the universities with a lack of adequate teaching on such topics as business plans, market analysis and risk. These are all areas which many people in the science and technology domain find it rather difficult to tackle. I think it is that familiarity that has to be gained at a very early age, which seems to be much more common in the USA, that we need to tackle. Equally I do find that many investors are poor at understanding the technology. They have spent a large part of their interest, their time, involved in the financial world and do not have the kind of facility again that people in many other countries have with the technology. That is partly cultural I think; it is partly an aspect of being interested. One can see, as I am sure we all have, from even looking at the press in the USA or Hong Kong, there are far more small items about technology which bring up the general level of understanding. The first issue I would say therefore is the communication process and that is something that needs to be tackled in a wide variety of ways. The second main barrier, I think, is the availability of what I would call true venture capital. We pride ourselves often in the United Kingdom as being second only to the USA in what we call our venture capital market. There is no doubt that there have been tremendous achievements in this area in the United Kingdom. I think there is a little bit of a misnomer here because most of that venture capital is what I would call development capital. It is capital which is available to firms which have a track record already; they have products already; they are trading and typically require quite sizeable sums of money, perhaps a couple of million pounds and upwards. There is even intense competition to provide that kind of funding to firms that are in that situation. The difficulty really is more in the area of getting capital for start-up ventures where there is just an idea; there is no trading record, there is no product at this stage, and that is very much more high risk. So if there is any means that we can provide to increase the flow of that high risk capital that would be a particular benefit I think. I was recently a member of the review board for the ESPRIT programme in the European Commission. The review board reports to the Council of Ministers, in fact, and acts almost like an audit body on the work of the Commission in funding ESPRIT. One of the main steps for the future we identified was the need to somehow facilitate the availability of this start-up capital because ESPRIT has been very rich in ideas and has had some tremendous achievements, but when you look at wealth creation that has come out of it undoubtedly there was a weakness there. I am very pleased to see that these recommendations are now being taken up and I will be very happy to leave this document with the Clerk. There now seems to be a move to form a venture capital fund to assist in that kind of start-up operation which could follow on from programmes like ESPRIT. That therefore would be my second area: the availability of true venture capital, partly again a cultural issue; it is a risk area and most of those in finance I think in the European environment are less willing to take the kind of risk that investors in the USA will as part of a balanced portfolio. The third issue, which as I mentioned is cultural and much more difficult to tackle, is the attitude to ownership of ideas and inventions. I have found certainly in countries like the USA that those who are wishing to develop their ideas recognise that they may have to give away a significant part of the equity in order to obtain funding. They are willing to take the attitude that they would rather have half the benefit at the end than not be able to get the project off the ground. I think there is a difficulty in the United Kingdom, but certainly in Continental Europe, in inventors wishing to put their arms totally around their idea, wishing to obtain funding, but not wishing to give away significant equity.

Lord Flowers

167. You make rather a thing of the education process, do you not? You want students to be able to write business plans as a result of what they are taught at school. That seems to me to be going rather far. Why should they not be taught how to examine a patient or taught how to engineer a motor car, all

Lord Flowers *contd.*]

sorts of things which are highly desirable but have to be learnt in due course. I do not think you can start teaching people business plans in primary schools. However, there are the modern curricula in technology and design which do take forward the concept of design manufacturing and an assessment of the success or otherwise in the project which is being used in schools now. I do not know whether that is what you had in mind? Moreover you seem to be saying as a weakness of the education system that investors mostly have little understanding of science and technology. I cannot understand why those who wish to invest do not appoint investors who do have an understanding of science and technology, there are plenty of people around.

A. There are a couple of factors here. There are undoubtedly some very good schools and very good universities where the climate of innovation is high and where this is tied into understanding of exploitation, but I do believe still there is a weakness there. I would not advocate going back to primary school but I think that the earlier one starts the understanding of exploitation the better. When I have been lecturing to universities as an invited speaker both in the United Kingdom and the USA, I have sometimes tried a little ruse on the audience to start off the lecture and get some participation by asking all of those in the audience who have started up or participated in a business venture, however small, to put up their hands. Typically you get very, very few hands in the United Kingdom; in the USA you will get a third or even a half of the audience putting up their hands. I think this does stem from business concepts having been introduced adequately early.

168. At what level? You say "early", do you mean in high school in the States?

A. In high school, yes. I think, perhaps, my Lord Chairman, just continuing on that point maybe, one of the difficulties is that teachers in general have relatively little experience in the business world or commercial world and I think that is very unfortunate. There have been schemes—and as far as I know these have been very successful where they have been implemented—for teachers to spend a certain amount of their time in local businesses to understand what is going on. I think that enriches the course they give tremendously.

169. Have you employed teachers in your own companies to do that sort of thing?

A. I have done that in the past and it was very successful; it was when I was working for GEC-Marconi. I think it brought benefits both ways. There is a cost associated with it and I guess this is one of the most difficult aspects just now when the education system financially is under pressure and industry is under pressure; it is difficult to release teachers and indeed to release staff in industry who can act as mentors and assist the process. I think I would not be popular for saying it, my Lord Chairman, but I think the school holidays would be a very advantageous time for teachers to participate in more of these schemes associated with industry. I think it would build links between the schools and industry to a greater extent than at present and it would enrich both sides also in giving a better matching of students from schools to industry. The second point I think, my Lord Chairman, that Lord Flowers made was in regard to investors. It is a difficult one to answer. A number of investors will make use of advisers who will assist them to evaluate technologies and I have assisted some of the venture capital companies myself in the process of evaluating possible investments for them, but I think that is really no substitute for an understanding on the part of the investor of the technology and them being able to make their own risk judgments because what they are really doing is making risk judgments when they are making their investment. I think a half way house is maybe to facilitate better advice to investors, but it is only a half way house.

170. Why are not the investors themselves engineers and scientists? I can assure you there are plenty of graduates from Imperial College where I used to be Rector who would go into the City and do just that sort of thing.

A. I know a number of those, but they are still small in proportion to those who do and manage funds and manage investments.

Chairman

171. You said—and of course this must be true—that it varies from university to university. In your experience is there a difference in the level of specification or instinctive understanding of commercial exploitation facilities where there is a well established reputable business school attached to the university?

A. I have not carefully analysed this situation but my impression is that where there is a university that has either a science park associated with it, a business school or activities that naturally draw a closeness with the business community, that does spin off into the teaching in the courses. I am a strong advocate of academic staff, or as I have just mentioned teachers in school, being closely connected with the business world or industry. I think another thing that universities and schools can do, particularly schools, because I come back to my point about trying to start as early as possible in this process, is to make more use of business people. I think in my notes I mentioned more use of people who have often retired early from the business community and who can be of great value in schools. I think it would need a little bit of structuring; I think there would have to be some format for this rather than just inviting people along in some unstructured way, but if there could be some attempt at a very broad framework or curriculum for the kind of involvement that these people might have and the things that they might get over to school children, it would be a great advantage.

Viscount Caldecote

172. You mentioned the problems of communications between investors and innovators, also I think between the two there is the problem of managing to bring the two together. Do you think the business schools in this country do enough to teach their students about what I would call the

Viscount Caldecote *contd.*]

management of innovation or management of investment and innovation? I suggested it some years ago to the Association of Business Schools, that they should take this much more seriously and it fell like a damp squib. If I could pass on to the seed capital point you made, which is a very important one. You made the point that there was great reluctance in the United Kingdom more than the USA for investors and innovators to sell some of their capital and of course this puts back the only source of seed capital, high risk early venture capital, to bankers and then you get companies starting off very highly geared and as soon as something goes a bit wrong, a development takes a bit longer, whatever it is, then disaster follows and they go bust very often. Why do you think that is? What more can be done? One of the problems, I think, which is generally agreed is venture capital companies are reluctant to put in small amounts of seed capital because of the high overheads involved and the difficulties of making money, putting in less than say half a million or maybe a million. Would it help if there was some scheme whereby the Government rather like the LGS—the loan guarantee scheme—underwrote the overhead costs in the early days of small amounts of seed capital? Would that be one possible way round it?

A. I think the business schools indeed can have an important extra role to play in this area, as also I think does the DTI, particularly at a local level, through the Business Links schemes, in catalysing contacts. I think really in regard to this aspect of seed capital one of the key things is to have better communication about what is available and what the needs of the investors are because it is quite true that the larger venture capital funds are not interested in the small amounts and there are so many people that really need £50,000, £100,000, or a few hundred thousand; that aspect and also dealing with a number of small investors is very complex and not very efficient for some of the main venture capital funders. Any scheme which can be started which allows a much better mixing and meeting of those small investors and small companies would be of great advantage. Business schools can play a role, I think DTI with their Business Links can play a role here without imposing a burden on Government funding, thinking of them as the catalyst effectively to the process, and the use of what one might call Innovation Fairs—there is one of these coming up very shortly in this country. This is very much an American model—effectively creating an environment, a geographical location, where those who are requiring money can come and put up their posters and show their ideas and those who have money can circulate around. I think that it does not need a lot of investment in terms of setting something like that up, but can be very valuable indeed. Done at a local level I think there are particular advantages too because many investors who are willing to put a certain amount of risk capital into businesses would like to do that in an area where they feel they can have some contact with the company rather than it being at the other end of the country or even in another country. That is why I focus back on the role of the business schools with their strong contacts into the local community and the DTI.

173. It has been suggested to us that it might be extremely valuable to have what we might call a multi-university science park with the infrastructure funded by Government. Do you think that would be a good idea? Would that help in the problems we are facing?

A. I think this is the kind of idea that might come out of the European Commission debate on this subject and associated with some sort of European venture capital fund. I would feel that that kind of thing might be appropriate in some of the areas where it was very important to get a critical mass of activity in some of the subjects which involve perhaps nanotechnology or some of the biomolecular areas. For a lot of innovation I think a "lean and mean" approach—an activity where you have close contact between a small enough group of people that can make fast decisions, is probably more the way to go. I would see the suggestion made being applicable more to situations of venture or innovation that require large amounts of funding and need a critical mass.

Lord Dixon-Smith

174. Inevitably, of course, we come back to the comparison between what we do here and what goes on in the United States. I wonder if you have any explanation for this disparity, particularly with the role of the business angels and this informal venture capital industry that is so vitally important at this start-up stage? Once you have got over that start-up stage we seem to be quite good and matters are reasonably taken care of but this basic start-up is a real problem.

A. It does seem to be cultural and I do think fortunately it is changing. Having lived for a period in Silicon Valley I noted the tremendous interest that virtually everyone in the community had, even those with relatively small disposable incomes, in the stock market and the interest in investing in ventures. It was as much a discussion at coffee time or at lunchtime as was the television programme last night. That is a cultural aspect. It will take us a time to change but I am very glad to say I think that is coming in this country. The other cultural part is the attitude to risk that I touched on earlier. There does seem—maybe associated perhaps with the way the United States has evolved, right back to the pioneer spirit—to be a greater willingness to move jobs, to accept risk. The attitudes I think in industry also tend to be different. I have been very interested to see the way that many of the large companies will buy up smaller companies; there seems to be a greater business dynamism which allows innovators and entrepreneurs to build up a business and then sell it on. They do not face some of the difficulties here when you have built up a business in the early stages and then you have the question of going into the next league of companies. There is a lot of dynamism where these large companies will buy up smaller companies, sometimes even when they are not doing terribly well, because the ideas, the intellectual property, are rather important and then that facilitates those people to go on to the next stage. Many of those people then will act as business angels

Lord Dixon-Smith *contd.*]

and the effect of their experiences, some good and some bad, in that process of building up those ideas into exploitation are particularly valuable. They tend to get recirculated into the community.

175. Are we good at spreading best practice in this country? Do we use our resources perhaps as well as could be done? You have mentioned this question of people with experience going on, the trouble is there comes a point in people's career where they want to stop.

A. Yes.

176. Given we all have a greater expectation of life how do we persuade them not to?

A. I think it is very much, my Lord Chairman, a matter of the interest and motivation. I think if I can quote one particular example: the scheme for independent directors that 3i have does seem to me a very valuable scheme. They do draw into that scheme a very large number of people to act as independent directors. They keep them well briefed and I think the people themselves feel very motivated to help the small companies. That is obviously a private sector venture. I think it would be ideal if we could see much more of that kind of activity to make better use of the skills that many people have.

177. I am slightly exercised in my mind as to whether the business schools are what I would call enterprise management orientated or whether they are what I would call business management orientated? There is a clear distinction between those two facets of the same subject.

A. Though I have not done a comparison really between, for example, the USA and the United Kingdom, my impression is that one would find more of an enterprise management culture associated, let us say, with the US business schools. I think that would be a difference I would expect.

Lord Cuckney

178. You have provided a very useful analysis of the different types of capital, seed and venture and development and investment capital, and I think we all recognise the shortage of seed capital is the greatest problem and with it inevitably is associated risk. Do you think that it is true in America the fact you have gone into Chapter 11 or been made bankrupt is almost a battle honour whereas here it is treated so differently and even with the comparatively recent development of being able to go into administration, it still brings with it a number of disadvantages for those associated with it. Do you think this is a problem that can be overcome in some way?

A. I do think that a lot of attention needs to be devoted to this area. It was something that again we brought up in our investigation on ESPRIT and the recommendations to the Council of Ministers. I am very glad to say I am not an expert on the bankruptcy laws.

Chairman

179. Perhaps given what Lord Cuckney says you should not be!

A. Yes! I do feel strongly that we have a situation that a single failure in the United Kingdom is usually fatal whereas, as you have indicated, in the US it is not. It is not infrequent that the most successful entrepreneurs have had a couple of failures and this is regarded much more as experience gained in the process. I think it would be ideal if we could find some mechanisms, some modifications to our laws on bankruptcy that obviously do not create difficulties in terms of people getting away from their liabilities, but do facilitate a situation where people can learn from mistakes, preferably at an early stage and then go on to use that experience to foster further innovations. One does come back to the point that was mentioned about the banking system because one of the difficulties that I have seen in a number of companies is that associated with the difficulty of finding venture capital. Companies then do go to the banks and probably they have to borrow more than they would like to, becoming highly geared. As was said earlier, the banks are certainly very risk averse and when there is a turn down in the trading conditions, which may be only temporary, that is the end of the business because the bank will foreclose on the loan. That is a very unfortunate situation. So if there was some safety net at that point, particularly a safety net where there were some early warning measures which could be put in place to assist that business through those difficulties, that would be a major step forward, I think.

180. I think the point made is quite right, it is not the capital element itself that is the problem, it is the gearing that goes with it and the involvement of bank support which is needed. However, one could have maybe a special class of venture capital equity which is known to be extremely high risk and nothing that matters is lost. It is very difficult if that is the basis for high gearing which is so often the case and that involves the bank lending.

A. One thing I know which causes a lot of difficulty for small firms is the aspect of cash flow. It is a problem, of course, in all business but for some small firms getting payments from some of the larger companies can be very difficult. This may well have been mentioned to you already. I think some countries do have legislation which makes it legally required that invoices have to be settled by a fixed time otherwise interest is payable. I think that is an area certainly which would benefit small firms very much if that difficulty could be ironed out because it would ease some of the very serious cash flow problems which arise from the difficulty of getting sizeable amounts out of large companies at times.

Lord Dixon-Smith

181. I was talking to the head of the insolvency department of a major firm of consultant accountants. He was saying that there is a quite identifiable path to insolvency for most businesses which, as an insolvency practitioner, he and his team can identify. There is a big problem because of Chinese walls in practice and of course they are not

Lord Dixon-Smith *contd.*]

allowed to get involved until the business is insolvent. If only you could get across these Chinese walls so that these people are prepared perhaps to look at more radical solutions and get their hands on things a little bit earlier in fact many, many businesses would never go insolvent at all, they would be picked up and straightened out. I just wonder if you would care to comment on that?

A. My Lord Chairman, I think an interesting example of where the relationship between banks and companies overcomes that difficulty is in Germany where the banks do seem to have a very much closer contact with the companies and get early warnings of difficulties and thereby are able to assist more. I would agree totally with what has been said that all too often—and that is why I talked about early warnings and safety nets—we get to a stage where it is a bit late to deal with the problem. A closer contact between the banks, where there is bank funding, and the company is vital. I am a particular advocate in the companies with which I am involved in putting a lot of effort into investor presentations, at least twice a year, which include the banking investors, those who have loaned money, very much as a mechanism of keeping all of those investors up to speed with the various challenges that affect the business, both positive and the difficulties or risk ahead.

Lord Flowers

182. The Technology Foresight Exercise in many ways has been very successful but do you think that it has had a real impact and improvement on the activities of SMEs in the United Kingdom?

A. My Lord Chairman, I have to say that I have not seen that as yet. It may be early days, I think, because most of those who have been involved directly with the Technology Foresight programme have been representatives from some of the larger companies and I think the effect will tend to work its way down the chain but as yet I cannot say that I have seen a major impact of this. Sadly, I think, in many of the smaller companies there is relatively little awareness of the programme. This is always very disappointing because those involved in these programmes put a lot of work into publicity both in the form of mailshots, reports, and all the publicity they can get in the media, but it does take a long time for this to work through. I would hope that in due course the result of this would come very much through the interaction between some of the larger and smaller companies.

183. You do not think any technological devices might help to make SMEs more aware?

A. Many of the SMEs are involved quite heavily in the use of the Internet and that is something we talked about. There are particular pressures, of course, on the smaller companies in terms of marketing budgets and getting awareness, particularly in global markets for their products. Of course the Worldwide Web and Web pages are absolutely ideal for this. Arguably more could be done in the electronic domain to create awareness of what Foresight is doing and how the outcomes of that could help the SMES.

184. May I ask one more thing about the Technology Foresight exercise. It is a sectorally organised activity. It has turned up a lot of ideas that are relevant in the sectoral context. A lot of the new ideas coming from basic research do not arise in the sector context at all, they are following their noses. I just wondered whether you felt any additional mechanism was necessary to make sure that ideas that arose in that way were not lost by a primarily sectoral exercise? Nanotechnology is the best example that has appeared so far of something that has been lost in the Technology Foresight exercise.

A. I think the only way to make sure that the smaller and medium sized enterprises take note of something like this is to put major effort into trying to show the way these developments can impact their business. The majority of people in those companies are very focused, obviously, on the key aspects of developing the business and arguably not looking far enough ahead in many cases. Therefore it is a question of really trying to put effort into showing, perhaps more than one might think is necessary, how these technologies could assist in developing these businesses.

185. The Technology Foresight exercise totally missed nanotechnology, it was looking at things from a sectoral point of view.

A. Yes.

186. I wondered whether you felt there was any mechanism the Technology Foresight people could adopt to avoid that type of thing falling between stools?

A. I have not been involved closely enough, I am afraid, with the Foresight exercise, my Lord Chairman, to comment on that.

Chairman

187. Thank you very much indeed, Dr Forrest.

A. Thank you very much, my Lord Chairman.

WEDNESDAY 29 JANUARY 1997

Present:

Caldecote, V.
Cuckney, L.
Currie of Marylebone, L.
Dainton, L.
Dixon-Smith, L. (in the Chair)
Kirkwood, L.
Tombs, L.

Letter and Memorandum by the British Venture Capital Association

I enclose a brief paper from the British Venture Capital Association ("BVCA") in response to the call for evidence by the House of Lords Science and Technology Committee which is enquiring into the Innovation-Exploitation Barrier.

A number of the questions raised are on the periphery of our areas of knowledge. Others are discussed in some detail in the recently published Bank of England Report on the Financing of Technology-Based Small Firms, to which the BVCA made a substantial contribution. We see no purpose in repeating the information contained in that report, which will be known to the Committee.

In addition, you will have received evidence from 3i plc, which is the largest of our members and which is active in the financing of innovation. Again, we do not propose to duplicate the remarks made by 3i, which we entirely endorse.

I look forward to presenting oral evidence before the Sub-Committee on Wednesday, 29 January. If acceptable to the Sub-Committee, I would like to concentrate on questions specifically relating to the provision of venture capital in relation to the Innovation-Exploitation Barrier.

D W Quysner
Chairman

14 January 1997

INTRODUCTION

The British Venture Capital Association ("BVCA") is the representative body for venture capital in the UK. Since the emergence of a venture capital industry in the late 1970s, venture capital investment in new and developing businesses has grown dramatically. In 1995, £2.5 billion was invested in 1,163 companies by BVCA members, compared with only £20 million in 1979. Of this £2.5 billion, £2.1 billion was invested in the UK and 88 per cent went into new companies, the remainder being follow-on financings to companies already in receipt of venture capital finance. The UK venture capital industry has now invested over £14 billion in over 14,000 companies since 1984.

BVCA members are engaged in a broad range of activity, which ranges from the financing of large buy-outs to the provision of seed and early stage capital for start-ups. Investment in technology-based companies accounts for a substantial proportion of investment. In 1995, BVCA members invested £494.6 million in 292 technology-based firms. Of this, £47.6 million went into 77 companies at seed, start-up or other early stage.

The number of specialist investors in technology is few and the volume of such investment has fluctuated. There is, however, evidence that activity is currently at a high level and there is a general belief that the quality of investments made in recent years has significantly improved. This augurs well for the future.

The largest and most active member of the BVCA is 3i, which has also submitted evidence to the Sub Committee. The following remarks supplement and support the views expressed by 3i in its submission.

1. *What is the current state of innovation in the UK?*

The BVCA is not able to calibrate the "state" of innovation in the UK and has no evidence to suggest whether the quantum or quality of such innovation is changing. In broad terms, however, it is considered that there is a significant level of innovation, principally in the universities, in the research departments of major companies and in entrepreneurially-based businesses.

For the purposes of this evidence, "innovation" is taken to mean technological innovation.

There is some evidence to suggest that the ingredients for successful exploitation of innovation have improved in recent years. For example, the UK has begun to see the emergence of a biotechnology industry, based on scientific research capability, which is capable of competing in world markets. The particular success of this sector may provide some insight into how innovation may be successfully developed in other areas.

2. *How successful have the DTI and other Government Departments been with their range of initiatives designed to stimulate innovation?*

The DTI and other Government Departments have a wide range of initiatives intended to stimulate and promote the commercial exploitation of innovation. Some of these, such as SMART and SPUR awards have provided companies with encouragement, small amounts of funding and a degree of credibility in the marketplace. Their impact is, however, not widespread and is not considered to be decisive.

The Small Firms Loan Guarantee Scheme ("LGS") has been successful in encouraging a significant number of start-up and early stage companies. For the most part, however, it has not been focused towards technology companies. There may be scope to amend or adapt the LGS so as to achieve a greater focus in this area.

3. *How effective in terms of product or process innovation and other exploitable outcomes are initiatives which encourage collaboration between industry and academia?*

There remain significant barriers to collaboration between industry and academia. In particular, although universities have in many cases put in place formal structures to facilitate dialogue, there remains a lack of common goals and of experience of the benefits of such activity. There is a widespread view that rapid improvements have been made in recent years and examples such as the successes achieved by UMIST and others may provide a model for the future.

4. *Does financing need to be improved for technology-based small firms during their crucial start-up and early development phases?*

The availability of finance for technology-based firms during their start-up and early stage is driven by a number of factors. Where funds are available for such investment, for instance through companies such as 3i or dedicated funds raised specifically to invest in such ventures, the supply of funding is constrained only by commercial considerations. For instance, it is frequently the case that technology-based companies do not have commercially competent management and are reluctant to introduce new personnel, in significant roles, who can provide the necessary skills.

There is a more fundamental issue, in that the supply of funding into this sector is potentially constrained by the structure of the savings industry in the UK. In recent years, there has been an increasing concentration of savings into a small number of major fund management activities which are judged as to their own performance by parameters which do not readily match with early stage technology investment. The position is exacerbated by the fact that in the period between 1984 and 1992, the first for which detailed data are available, the performance of such investments was inferior to that achieved in other investment categories, such as Stock Exchange investment. Fiduciary considerations may deter institutional investors from committing to a sector for which performance is not readily demonstrable.

5. *What other support systems could be introduced to ensure maximum advantage is taken of innovative ideas that originate with individuals or, for example, academia?*

There is a role for Government in helping to overcome some of the mismatch between the financial characteristics of early stage technology companies and the financial needs of investors. The introduction of Venture Capital Trusts has provided a facility to change the risk/reward ratio for private investors in small companies.

There may be ways in which Government can encourage a higher level of institutional investment in technology-based companies, for instance by underwriting some of the financial risk.

The BVCA is currently working with the DTI and others to explore ways in which resources can be brought to assist promising, innovative ideas to develop business proposals which may attract funding. This initiative should be developed further.

On a more general front, it must be recognised that the commercial exploitation of innovation is part of a complex structure, at each stage of which intervention may be valuable:

Secondary education where, for instance, the BVCA has recently recommended, through the Tony Lorenz Memorial Trust, support for Young Enterprise, an organisation which promotes the understanding of business in schools.

The continuance of high levels of financial support for fundamental research in universities, without which innovations can not be expected to develop.

The encouragement in academic establishments of a greater awareness of commercial issues, so as to facilitate the transfer of technology from academia into the business world.

The encouragement of changes in the structure and operation of capital markets. Many aspects of this are dealt with in the recent Bank of England report, to which the BVCA provided substantial input.

The continuing development of an entrepreneurial culture in which the unique skills of those who are able to convert ideas into business reality are both recognised and rewarded. In this respect, the BVCA has successfully campaigned for changes in Capital Gains Tax as it affects entrepreneurs. It is considered, however, that fiscal measures could further improve the picture, for instance by the introduction of further specific CGT reliefs for entrepreneurs.

6. *Is there institutional inertia towards the funding of technology-based small companies? If so, to what extent may this be due to financiers' unfamiliarity with science and technology concepts and what should be done to address this?*

There is an awareness amongst many institutional investors that they lack the skills and resources to assess certain kinds of investment.

There is, however, a small community of institutional investors which is committed to and active in the technology sector. There are difficulties with specific technologies but these can be overcome by appropriate recruitment and by the use of networks of advisers. Demonstrable success will inevitably attract further support to the sector.

7. *The Committee recommended tax credits for research and development in our previous enquiry. Would this still be an effective way of fostering innovation and how should they be introduced to ensure that they are roughly cost neutral?*

Tax credits for R&D may help foster innovation in larger companies. For start-up and early stage companies, however, it may be several years before profitability is achieved. The transferability of tax losses may merit consideration. It may, however, be more fruitful to concentrate on the provision of incentives for investors, rather than on the companies in which they invest. The cost of any incentives, in terms of loss to the Exchequer, has to be judged against the potential benefits in terms of new job creation, PAYE, VAT and other positive effects which may result.

8. *How has the Technology Foresight Exercise influenced the availability of development funds for innovative ideas that were not given short term high priority status?*

We do not yet have any evidence that the Technology Foresight Exercise has had an effect in influencing the availability of funds. It has, however, played a part in stimulating what is currently an active and valuable debate.

9. *Has tax relief introduced in 1992–93 for individuals' expenditure on vocational training had any impact on the status of continuing professional development, particularly for employees in small firms?*

We have no evidence on this issue.

January 1997

Examination of witnesses

MR DAVID QUYSNER, Chairman, British Venture Capital Association and MR STEPHEN SALTAIRE, 3i plc, were called in and examined.

Chairman

188. Mr Quysner, welcome.

(*Mr Quysner*) I would like to introduce my colleague, Stephen Saltaire, who is an executive at 3i, which has also submitted evidence to the Committee.

189. Is there nothing you want to add by way of opening statement?

(*Mr Quysner*) No.

190. Perhaps we could begin by an explanation of why there has been such a meteoric rise in the venture capital industry since 1979. What factors would be critical for similar rates of growth in the future, always assuming that you believe that that is desirable?

(*Mr Quysner*) I think we need to go back a little further than 1979. If we look at the findings of the Bolton Committee in 1971 it was reported that we were already beginning to see the emergence of a number of venture capital companies in addition to 3i, which emerged just after the war. My own company, Abingworth Management, which specialises in technology investment was started in 1973, and in common with quite a number of venture funds, was started because there was a perceived opportunity reflected from the USA, and based on what was happening in the Boston area and in California. There is a second factor which goes back to Competition and Credit Control in the early 1970s, and the more aggressive behaviour of the banks in the small business community. Those factors came to a head towards the end of the 1970s and the beginning of the 1980s, when a number of venture capital firms were established, many of them with a view to investing in early stage companies,

Chairman *contd.*]

some created by the banks to invest in development stage companies principally, and in many cases seeking to compete with 3i, in which they were shareholders. I think there is a further factor which is that from 1981 onwards, with the 1981 Companies Act, it became easier to undertake restructuring of companies through management buy-outs. It is also the case that BVCA lobbying for changes in the UK partnership law in the 1980s allowed for more flexible vehicles to be created into which capital was introduced for onward investment in private companies. It is also true to say that we are looking at something which has grown from a very low base. In fact the numbers we ought to look at are really from 1984 onwards which is the time from which data was generally available on the venture capital industry. From that time we have seen an increase in the total volume of investment from something of the order of £190 million to last year's total of approximately £2.5 billion. It is important to understand that that financing falls into a number of areas, and I think this Committee is principally concerned with only one of those areas. When we talk about venture capital in the United Kingdom, we include all forms of investment in private companies. That ranges from small amounts of money going into early stage technology companies, right through to buy-outs, privatisation buy-outs perhaps, involving very large companies. I want to concentrate on your area of interest which would be the smaller innovative company rather than the larger buy-outs. The data includes all those companies. The growth has come from a combination of favourable economic circumstances, a lot of measures brought in by a number of governments led by Margaret Thatcher seeking to encourage entrepreneurial activity. It comes from the model of the USA and the growth of technology companies there. It comes from changes in the competitive attitude of banks and other sources of funding. On your question as to whether we can continue to see this kind of growth, it is important to understand that it takes time to build up the infrastructure which will allow growth to continue. We are only just beginning to see some of the fruits of investments made in some of the structures created in the early and mid-1980s, and we are just beginning to see the results of some of that investment. I shall contend later that we have an environment now which is more conducive towards innovative investment than any I have seen in the 20 odd years I have been in venture capital, an environment which is some way ahead of anything which, for instance, our European competitors have.

191. You said that we were perhaps particularly looking at the small start-up companies and the environment to get them going, but of course innovation and the exploitation of innovation is not exclusively the prerogative of small companies.

(*Mr Quysner*) Our members do invest across the spectrum and will frequently invest in established businesses. It may be the case on occasions that they would invest in an established business to finance some innovative activity, a move into a new product area, for example, but for the most part, our connection with innovation will be in smaller companies, who have particular financing needs which are not met by mechanisms available to larger companies, for instance the quoted markets.

Lord Tombs

192. Mr Quysner, could you tell us what role your association plays, and might be able to play, in removing the barriers which seem to exist between the creative phases of innovation and the exploitation of ideas? I have in mind the comparatively small sums of money, perhaps £100,000.

(*Mr Quysner*) There are a number of things we try to do. First, we are a source of significant information and publications, and we also have a Web site to provide data for small companies on the availability of certain kinds of finance. Although it lies slightly outside the area which is the principal interest of our members, we have spent a lot of time and effort on developing the business angel network in the UK. For instance, we produced a publication, of which I think to date we have given away 30,000 copies in the last three years, which is a directory of business angels and the business angel network. This is an effort to increase the profile of the business angel environment, and to put angels in touch with companies. Information is a very important part of what we do. We spend a lot of time with the business schools and with academics generally, and we sponsor research into various aspects of smaller company funding. There are some 25 or 26 of our members whose names are in the BVCA directory who will look at proposals of less than £100,000. That is 26 members out of a total membership of 110 or so. There are some of our members who will look at quite small amounts of money. It should be said that if we are looking at innovation which can lead to the creation of substantial businesses, businesses that may be capable of competing internationally, that very small amounts of money are seldom required.

193. Seldom, but they may be important when they are required.

(*Mr Quysner*) That is the case.

194. We appreciate that the appraisal costs are proportionately very high for small sums of money. That could turn a lot of people away. I think, my Lord Chairman, it would be helpful to have a copy of the business angels document and an indication of the amount of money that is available, arbitrarily at £100,000 or less over the past year.

(*Mr Quysner*) I can derive that information for you. I think you might have been interested to see in yesterday's Financial Times an article on business angels. This is a publication by a man called Patrick Codeney, "Business angels: tapping potential individual investors in Britain", in which it is suggested that the amount of capital being provided, in many cases alongside venture capital firms in the UK, may have averaged as much as £265,000 per angel and suggests that the pool of business angel money in the UK is much greater than was previously thought to be the case. In the USA there is evidence to suggest that the quantum of business angel money is something like five times the quantum of the organised venture capital industry's money

Lord Tombs *contd.*]

available for investment in innovative companies. The role of the business angel which we are trying to foster is very important and we do try to work alongside business angels to fund companies and fund innovative companies.

195. Are these business angels generally passive or active?

(*Mr Quysner*) It varies enormously. We have seen, for the first time in this country in recent years, the emergence of angels who have successfully exited innovative companies going back into the same industry. Perhaps I can give you an example. The British Venture Capital Association sponsors every year a competition called the Venturer of the Year Award, which is done jointly with the FT and Cartier. The winner two years ago was a man called Bob Jones in a company called 3Com Sonix. The interesting thing in that situation was that it was the third company which he had successfully started and built up and exited. That is a phenomenon which is quite unusual, but it is becoming more common in the UK. What would he do for the fourth time? He might start another company in the same sector, or he may decide now to become a business angel, and invest in a number of companies and help them with his experience in the sector in which he made is money, which happens to be the computer networking business. He would be an active angel because he would choose to invest in sectors which he knows and understands and where he can add value. I think the introduction of the EIS scheme has attracted purely tax based angels, some of whom do not become actively involved in the company they invest in, but nevertheless they are welcome as investors. One of the other factors which has been beneficial in recent years, has been something which the BVCA has lobbied for, the introduction of capital gains roll-over relief, where successful entrepreneurs can reinvest in an appropriate business and roll forward their capital gain. Our members do work with angels. I know that 3i has a very active programme of investing with angels particularly in some of the offices where there is a high technology content. The Cambridge office and the Reading office have many investments where angels are investors.

(*Mr Saltaire*) It is not infrequent at the early stage of a technology application for us to team a business up with an angel for the next stage of its development before even 3i will invest. In a sense, that is a more efficient use of management and capital than making our own investment, and we will actually invest at the next stage.

196. And better for management?

(*Mr Saltaire*) Indeed.

Chairman

197. What I have read about the success of business angels in Silicon Valley seems to suggest that by habit they are almost automatically very actively involved in management and development of business, even to the extent of controlling and heaving the initiator of the business out in order to get other management in. Do you think that the system is right to encourage business angels to take on this development of new businesses as a career? Have we got the emphasis right to make this happen?

(*Mr Quysner*) The first thing to say is that we are much better than we were at doing this. There is a momentum in the business angel movement which is very significant. The second thing to say is that we compare ourselves frequently with the USA but the environment in the USA has many differences. In the USA the famous Wisconsin dentist is a very frequent business angel, but without playing any part in the business. What we have not seen in this country to the same extent is successful entrepreneurs leaving businesses which they have built up over a number of years and participating in new smaller innovative businesses. We have not seen that to the same extent as in the USA, but we are beginning to see it.

Lord Currie of Marylebone

198. The large institutions, the pension funds and insurance companies, seem to dominate the British venture capital market. How does that affect the nature of the investments that take place?

(*Mr Quysner*) It is true to say that the large institutions, particularly the pension funds, have been strong supporters of venture capital throughout its life. In the case of the British pension funds, the percentage of the total funding for venture capital, which they have provided, has tailed away in recent years. However, the monetary values have remained very steady. It is important to understand that the venture capital industry is merely a conduit for funds which arise through our savings industry into companies of various kinds. Certainly the independent venture capital funds are creating and selling a financial product, which is sold to the pension funds, insurance companies and so on. Perhaps I could go back and deal with one issue, which is that the venture capital industry really has three segments. 3i is in a segment entirely of its own, it is a very special vehicle, and also because of its sheer size it is in a category of its own; the so-called captive venture capital funds, those created by and owned by the clearing banks, some insurance companies and so on; and the independent venture funds who are the ones that go out and raise money from time to time for investment in ventures. That is the group we are talking about when we talk about funds flowing from the pension fund industry and going into the independent sector. The issue is one of persuading a pension fund that it should allocate a proportion of its assets to a particular asset category. Most pension funds will allocate to equities and bonds and have sub-allocations within those categories. How can we persuade pension funds or insurance companies to allocate a proportion to a particular kind of venture capital? The principal attraction will be if we can demonstrate that financial returns will be superior to other forms of investment to match the perceived risk. At the moment it is less difficult to persuade pension funds to invest in a buy-out fund than in an early stage technology fund, because the financial returns of the buy-out sector have been demonstrably higher in recent years. So an issue in terms of what influence the pension funds or insurance companies have on what we do, is can they

Lord Currie of Marylebone *contd.*]

be persuaded that it is going to make them a superior financial return. Investments made in innovative companies in the early 1980s did not produce the kinds of return which we would like to have seen, for all sorts of reasons to do with the lack of structure to support those companies which I maintain is now beginning to emerge. The job of the independents, like me, over the next several years is to persuade pension funds to look forward to the returns which they may expect in the future and not to look too closely backwards at the returns that were achieved in the very early stages of trying to do some of the things we are now doing quite well.

199. Is that why a small proportion goes into high tech start-ups and seed capital and so on?

(*Mr Quysner*) To some extent, yes. When you talk about a small proportion we must remember that the total amount of money which we say goes into venture capital includes everything from early stage to buy-out. If we can exclude the buy-out segment I have some data which I would like to give the Committee which would suggest that the amount of money which goes from venture capital into early stage investment of all kinds, for instance, compares favourably with the USA in terms of GDP. Where we do not compare so favourably is in terms of the amount which goes into technology investment and that is a function of many things. Even on that score we compare extremely favourably with all our European counterparts.

200. Is there an issue about the minimum size of such investments? Is there a problem of getting small amounts for small start-ups?

(*Mr Quysner*) It is the case that there are difficulties caused by the overhead structure of venture capital activity. The typical cost of running a venture firm which is investing in a later stage may be between one and two per cent. The typical cost of running a seed capital fund where executives are spending a great deal of time on individual companies, may be as much as ten per cent. That clearly has an impact on the prospective returns. That is a difficult issue, and will mean that the pool of capital in that area might be restricted.

Chairman

201. Is there any evidence of what I would call the success to failure ratio in this field?

(*Mr Quysner*) I do not have any specific evidence. What I can say is that in the USA the success rate may be in the less than 20 per cent area, but the orders of magnitude of that success are sufficient to pay for a lot of failure at the other end. The order of magnitude in the upside of the UK investment is often lower.

Viscount Caldecote

202. You mentioned business schools. Do you think that business schools do enough to bring this sort of problem to the attention of their students?

(*Mr Quysner*) It is certainly the case that the entrepreneurial courses at business schools are extremely popular. It is also the case that the number of students who leave business school and become entrepreneurs is remarkably few. There are complex reasons why that may be the case.

203. Could you suggest one or two?

(*Mr Quysner*) I think some of them are cultural. The entrepreneur is not as highly regarded perhaps in this country as, for instance, in the USA. Many MBAs find attractions in using some of their other skills in the City perhaps. Perhaps we need some more incentives, more financial incentives to help people get into business.

204. You mentioned the problems of overheads on small investments. The government in the loan guarantee scheme take quite a share of the risk of guaranteeing a substantial portion of the loans. Do you think it would be helpful if the government were prepared to give some sort of financial help to those who invested small amounts, in proportion perhaps to the smallness of the amount?

(*Mr Quysner*) I think that could be an interesting thing to examine. The thing that concerns me most about the loan guarantee scheme is the small amounts of money which have gone from LGS into innovative business or technology based business. The Bank of England, in a report recently published, makes that point very clearly. It would be interesting to look at ways of channelling more LGS money into innovative business as opposed to others.

205. I am not clear whether you think there is enough of the so-called seed capital or whether you think that is still quite a major problem?

(*Mr Quysner*) Can I look at that in a number of areas? One of the issues which we have struggled with over many years is that of how to migrate technology from the universities into the commercial world. There is a difficulty in that area. I spent some time at one of the universities talking to their technology transfer team on this subject last week. The university has limited funds to look after the intellectual property which arises in its laboratories. The resource is available to provide for two or three people sitting in a technology transfer unit and they are required to be able to identify those pieces of intellectual property that the university will support by funding patent applications. That, in itself, is extraordinarily difficult, and the university has limited funds with which to do that. We need to find better ways to support universities to do that and find more innovative ways. Perhaps I can give an example, which I think is useful. My own company had an investment in a business which we started from nothing, by identifying an individual, who was a professor at a major university, and helping him to develop a business plan and raise some seed money to take the project forward, and that business developed into a company in biotechnology. Because the man we were backing had established relationships with the university and with people who were still working in the laboratories in the university, and because universities tend to be small places and in certain technologies people tend to know what is going on throughout the world, it was possible to reach an agreement with the university which said that if the university staff working in the laboratories wanted to collaborate with the

Viscount Caldecote *contd.*]

commercial company, then the company would agree with the university to fund the protection of the intellectual property and a licence would be negotiated whereby the university would benefit if the intellectual property were exploited. That kind of arrangement can work, but it is not widely practised. That is one area where there is difficulty because the universities have limited funds and there is a difficulty because there is not enough dialogue between the commercial world and the university world. Over the last several years we have seen many successes. The University of Manchester Institute of Science and Technology has spawned a dozen or more companies over the last few years, a number of which have been very successful. So we are beginning to see that happen and happen to a greater extent than previously, but there is still a lot to do.

206. Do you think that the successor of the business expansion scheme, the EIS, is a valuable operation? Is that doing good? I think it is a freer organisation than the business expansion scheme, where you were not allowed to be a director if you put money in, but that has been abandoned. Is it more effective?

(*Mr Quysner*) It has been improved in a number of respects. The basic concept is very attractive. It is still slightly cumbersome in its administration. There are aspects of it which still may need to be looked at further. A tax incentive to invest at an early stage in companies clearly can be of benefit. I am attracted by remarks made in a submission to this Committee by another venture capital firm, Apax, which talks about special treatment for entrepreneurs, special taxation treatment for entrepreneurs. I think that deserves considerable attention. We have a situation currently in funds which I manage where it will be done through a partnership, and the partners will be pension funds, for example. If I make an early stage investment in the company alongside 3i and the entrepreneur, and the company is successful, then I exit, 3i will pay no capital gains tax because it is an investment trust, my partners will pay no capital gains tax because they are exempt and the entrepreneur will pay capital gains tax of 40 per cent, having created a great deal of wealth and having created tax revenues, and we would like to see that situation reconsidered. We think there is scope to focus incentives on the people who create wealth for us.

Chairman

207. Mr Bill Gates has got over the barrier.

(*Mr Quysner*) Bill Gates, of course, was helped by an SBIC, as was Steve Jobs at Apple. They were certainly helped to get off the ground by a tax based structure.

Lord Dainton

208. A propos your remarks about universities, which seemed to me to be slightly critical, we have of course had other criticisms saying that their central industrial liaison offices are not very good at spotting what can be exploited in the departments or maybe the departments themselves are slow in coming forward. The one specific criticism has been that they tend prematurely to protect their intellectual property rights. What are your observations on this? Are there things that the universities could do to improve this relationship to ensure that more good ideas come to the notice of the venture capitalists?

(*Mr Quysner*) My earlier remark was not intended in any way as a criticism of the universities who are trying hard to address these issues.

209. But are they good at addressing them, even though they are trying very hard?

(*Mr Quysner*) They are getting better.

210. What more could they do?

(*Mr Quysner*) It is a complex issue. A university that may have departments covering a very wide range of activity, may find it very hard to deal from the centre with the issues which those departments create. The difference in the USA is that there is fundamentally a much greater awareness amongst academics of the commercial value of their work. One thing which I know a number of universities and perhaps all major universities are trying to do is to include on PhD courses and in the university environment generally the opportunity to look at business issues for research students. That is something in which we participate. BVCA will go along to universities and talk to PhD students about what we do and try to get into their minds that what they are doing may have commercial possibilities.

211. It is 20 years since I, in another role, initiated a four year engineering course of a special kind, and I asked for a survey which was done of the employment of those on these courses. It turned out to be very interesting. A large proportion of those engineers did not carry those ideas forward into industry, but tended to move into those areas where the money was more attractive. Although the courses were good at attracting people, they switched into non-engineering roles which did not benefit industry. Have you any observations on that?

(*Mr Quysner*) Thomas Hardy, I think, said that the tendency of rural populations to move towards cities is that of water to move uphill, it is driven by steam. The tendency of engineers to move to the City is that they are driven by money.

212. We can ill afford the loss of such people remaining and developing good engineering or scientific ideas. It seems to me there is a gap too, whereas in the chemical industry, what is done in the university is much more similar to what is done in the firm, and that makes the transition much easier.

(*Mr Quysner*) Absolutely.

213. How in those other areas can one make the situation as beneficial as in those two instances?

(*Mr Quysner*) That is certainly the case and one of the reasons why biotechnology has been a particularly successful area for venture capital investment. There are other disciplines in which it is easier to make the migration and particularly situations which have long lead times. I would think of advanced materials, perhaps projects which involve fundamental technologies, display technologies, for instance. There is a much more difficult issue where the technology arising is, whether it be in universities or other research

departments of major companies, of limited product life. Certainly an issue we face frequently is that of whether we are being asked to finance a product, or something which is capable of being a business. As you say, biotechnology frequently will be fundamental, enabling technology on which a whole business structure can be built. In many other areas of engineering it may be a single product which may be more difficult to exploit commercially and which needs to be exploited more rapidly.

214. One of the things that struck me in my academic life, and I was frequently a consultant, was that some departments had very few people consulting in industry and had a low awareness of it. That problem was not solved by bringing in people from industry to the university because it was a second or third rate priority. Is there any suggestion you can make to improve that situation? Perhaps you do not believe it is true.

(*Mr Quysner*) I think it may be true. I have no specific suggestion. Perhaps I could pick up a remark you made earlier. If it is true that the engineers are moving away from engineering and going into the City, there may be a beneficial effect there. One of the criticisms often made of the City is that it does not understand the technology in which it should be investing. If that is happening it may not be entirely bad.

215. They do need some industrial experience before they do that and so many of them go direct to the City. Does that nod denote assent?

(*Mr Quysner*) It denotes assent.

Lord Cuckney

216. Can I come back to an earlier discussion we had on seed capital and the problem that was identified of a comparatively small commitment of capital where overhead costs are so high? How much does industry do to overcome that by capital structure, by innovative forms of venture capital? Do you not already in part recognise that deferred payment, founder shares with special rights are valuable in some years to come?

(*Mr Quysner*) I think the industry has developed over many years, and 3i was at the forefront of doing these things and developed financial structures which will help adjust the risk/reward ratio. The issue raised in relation to seed capital was one of overhead costs of making that type of investment and it is certainly the case that an individual executive may spend a great deal more time on one small innovative company, than on something which is going to absorb a much larger quantum of investment and produce perhaps a not dissimilar financial return. I think the issue is to do with the risk/reward ratio. The financial structure can help swing that. A differential of perhaps 800 basis points on the cost of an individual transaction is large.

217. Then you mention in your evidence on page three, two particular points I would like to ask you about. One was the problem of technology-based companies not having commercially competent management and the other was that there is only a small number of, usually institutional, investors, committed to an active technology sector. How can they be overcome? On the commercially competent management issue, what can the industry do about it? I seem to recall 3i had a fairly highly developed non-executive director register which was of considerable value. Does that happen more widely in the industry? Are there other ways of overcoming this?

(*Mr Quysner*) 3i has for many years developed a non-executive director programme which has played an important part in its investment activity. I think it would be generally the case of the BVCA's members that they maintain a register, a body of people to whom they may turn to help their investing companies. That is a valuable resource. In the case of technology based companies the kind of people to whom one would turn are slightly different. We tend to look for people with more technical backgrounds than in other cases and finding people of that kind is difficult.

218. Where one is concerned about the commercial competence of management, cannot the non-executive directors make a significant contribution?

(*Mr Quysner*) Absolutely.

Chairman

219. When venture capital is being put in would it ever be normal for the investor to require participation of the management to ensure that the integrity and skills are required or is that rare?

(*Mr Quysner*) It is quite rare, to be honest, for there to be participation in the management, the day to day management, but it would be very frequent to require board level representation and the information to enable the investor to track what the company is doing and help instigate change in the business. The more the spectrum swings towards the start-up and early stage businesses, the more that is the case.

Viscount Caldecote

220. It would not be unknown to say that the company in which you want to invest must have a financial director?

(*Mr Quysner*) Yes. It is commonly the case that before making an investment the venture capital company would insist that steps are taken to recruit, in the first instance, a finance function and secondly a marketing function.

Lord Cuckney

221. In your evidence you said that there is only a small community of institutional investors committed to the technology sector. Presumably the main reason is because of the track record of such investments in recent years. Is there any other reason?

(*Mr Quysner*) I think there is an issue to do with critical mass. If we look again at the USA, for all sorts of reasons that are well documented, a venture capital industry grew up, certain technologies grew up in the same environment, and around that there grew up supporting activities, NASDAQ for

Lord Cuckney *contd.*]

instance, the brokerage community that follows NASDAQ, a community that understands the technology that has grown up in this circle. We have not yet developed the momentum that allows that to happen in the UK, although we are beginning to see that happen. It is the case also that returns from early stage technology investment in the early 1980s were not sufficient to attract a lot of capital, but there is a lot of evidence to suggest that more recent investments in early stage innovative companies has been very good. You will see, for instance, that one of our members has recently launched an investment trust which will focus on a range of technologies based in Cambridge. That is partly driven by the fact that it has demonstrated a very good record in this sector in recent years. As those results come to the fore in the next few years, I would expect to see a good deal of money going into these activities. 3i has been very active in the past ten years, particularly through its Cambridge and Reading offices, investing in a wide range of technologies, and the results from that have been very favourable, and it is encouraging.

Chairman

222. Somewhere in our papers there was an examination of the attitudes of the promoters, the originators of these small companies, and the most common motivation seemed to be to develop a life style that they thought was congenial rather than to develop a product or a market. Is this something that you have run into, and is it an inherent obstacle towards getting these firms developing swiftly?

(*Mr Quysner*) There is a segment of the market place in which that may be true. The real entrepreneur, the one who is driven to build something, to create something of value is a fairly rare commodity. Certainly we look to invest in companies driven by entrepreneurs who want to build something of value that will last over time, and we are less interested in companies built to be life style businesses, but there is a mixture.

Lord Kirkwood

223. I would like to ask what effect the introduction of the EASDAQ exchange has had on the raising of capital for technology-based companies, and whether this has had any influence on investment decisions by the venture capital industry. Could you preface that by explaining to me, at least, what EASDAQ's function is?

(*Mr Quysner*) Can I step back slightly before doing that. First of all, for investors in private companies it is important that there should ultimately be some exit route, a means to realising the value of an investment. There was a time in the early 1980s when the principal exit route was a listing on the stock exchange, which was a difficult feat to achieve. The barriers were high. The unlisted securities market in its day did help smaller companies to get to that stage, and that in turn helped fuel the venture capital industry, because there was a physical exit. When the USM was phased out, and phased out principally because of changes in European law, which meant that the differentiation with the official list was not very great, the BVCA and others sought to replace it in some way, and that led to the creation of the Alternative Investment Market. I was involved in the committee that led to the creation of that and I was on the committee after its establishment. That was very favourable because it provides the next stage for a company having been brought through the venture community to go to the public market to raise money. At the time the creation of that was being debated there was a general discussion about whether we had a model in the USA with their NASDAQ market, the National Association of Securities Dealers driven market, and that led to discussions as to whether there could be a European version of that, and that was launched last year, and now has a number of companies traded on that exchange. The concept of EASDAQ, as I interpret it, is that it would be a market designed for, targeted at a particular kind of company and that is the high growth rate, technology driven business. It is not aimed at the more conventional industries. It is not aimed at companies that grow at low rates. It is not aimed at financial companies. It is aimed at the Apples and Microsofts of Europe. It is too early to say whether EASDAQ will be successful. It has only been active for a few months now, but the fact of there being yet another market out there which is a potential source of funding to help companies grow further, is undoubtedly part of this equation which is creating a favourable environment for venture investment. I would add that the Stock Exchange has also been very helpful in a number of ways in promoting change, not only through the introduction of the AIM market but also by introducing changes to its rules. For instance, chapter 20 of the Yellow Book introduced a few years ago allowed for the first time biotechnology companies to go public at an early stage in their lives. We now have something like 22 biotechnology companies on the market which were all venture capital backed, including some which are undoubtedly world class businesses.

224. Is that the normal route, to become a public company or do they get absorbed into larger organisations? Does it matter? Is one healthier than the other?

(*Mr Quysner*) Trade sales are in fact the commonest exit route for venture companies. Most investors at the time of making the investment would like to feel that either route was a possibility. In the particular case of biotechnology companies, I repeat this particular instance, because biotech has been very successful in recent years in the UK, the amounts of money that they require to fuel their continuing development programme are substantial and so public offering is often the chosen way forward.

225. You would not say that one route was more healthy for the UK economy than another, to establish smaller or growing independent companies rather than getting absorbed?

(*Mr Quysner*) I would not say that one was necessarily to be preferred. Not all the companies of course are absorbed by foreign purchasers, if that is your question.

Lord Kirkwood *contd.*]

(*Mr Saltaire*) In respect of that, sometimes a trade sale can be of benefit in terms of established routes to markets in some countries like the USA. It is sometimes helpful for a business to go to a trade purchaser and that in turn helps the UK economy.

Chairman

226. Many thanks to you and we have enjoyed listening to you. Do you have anything you would like to add?

(*Mr Quysner*) Thank you for the opportunity of talking to you. I am sure some afterthoughts will occur.

Memorandum by the Association of the British Pharmaceutical Industry

1. *What is the current state of innovation in the UK?*

Before commenting on the current state of innovation, it is worth reviewing the "cycle of innovation" as it affects the pharmaceutical industry not just in the UK, but in the rest of Europe, USA and Japan.

- Patentable, innovative products and processes arise from basic research carried out in the industry's own laboratories, or in collaboration with academia. This basic science is affected in turn by the funding available, and by the availability of good scientific training and a well supported education base.
- Once developed, novel products have to go through a lengthy regulatory process before reaching the patient.
- Issues affecting the commercialisation of the product, and hence profitability include demand side controls and public expenditure pressures.
- The further investment for the discovery and development of new products has to come from the sales of the few successful products arising resulting from the initial R&D investment.

Innovation within the pharmaceutical industry demands great amounts of such risk capital. The average cost of discovering and developing a major new medicine is approximately £200 million, and it takes an average of 12 years from the filing of a patent to the launch of a medicine.

Almost all of the pharmaceutical R&D expenditure in the UK is funded by industry itself (ie from sales of the successful products) with no guaranteed returns on its investment. On top of the need to finance this cycle of innovation, pharmaceutical companies must also provide a return to their shareholders.

It is therefore important that the economic and political environment in which the industry operates is stable and supportive for research, so that present projects may be maintained, and the investment in future work undertaken.

The pharmaceutical industry carries out almost a quarter of all industrial research in the UK and spent nearly £2 billion in R&D in 1995. Around 20 per cent of its output, and 25 per cent of its sales are spent on researching the medicines of the future. The pharmaceutical industry also makes a contribution to Britain's trade surplus out of proportion to its actual size. After North Sea oil, the pharmaceutical sector still shows the country's second biggest trade surplus. This success is founded on a long record of innovation, with five of the top 20 medicines prescribed in the world today being discovered and developed in UK laboratories.

Increasingly, biotechnology and the biomedically related sciences are playing a major role in new develpments in healthcare, including the production of new medicines and biopharmaceuticals, new methods for their large scale production and new and more accurate genomic and immunological diagnostic tests.

Britain is home to approximately 14 per cent of the world's SME bioscience companies, accounting for over 60 per cent of the European industry. New companies are being formed in the UK at the rate of one or two each month. Over 90 per cent of Europe's listed bioscience companies are in the UK.

It has been estimated that by the year 2000 biotechnology dependent sales by the UK biosciences industry could account for over £9 billion.

The UK pharmaceutical and biosciences industries depend upon a strong academic science base here. The Association has continued to express strong concern over the threats to the continued well being of the industry in the UK as a direct result of the decline of the science base, and the increased activity of other countries in this area. There is no doubt that in the UK life sciences and biomedical R&D are national assets that must be nurtured, but there is clear evidence that the UK is falling behind. There continues to be a high standard of curiosity driven research in a limited number of leading academic institutions leading to potentially exploitable discoveries, but problems concerning the declining state of equipment, the lack of practical skills of many graduates and the lack of funding of university infrastructure is beginning to affect the competitive position of the UK.

2. *How successful have the Department of Trade and Industry (DTI) and other Government Departments been with their range of initiatives designed to stimulate innovation?*

Many member companies of the Association have had experience of Government Department initiatives established to stimulate innovation and collaboration. Those include the collaborative PhD studentships and the LINK scheme. Both of these schemes are of value in terms of training, building links into academic centres of excellence, developing and sharing new scientific knowledge. LINK projects provide underpinning research, often of generic nature, so that the information generated as a result of the publication of the results of the research has potential benefits to the wider science base.

Many of the schemes do appear to be heavily focused at start-up companies, and this is a matter of concern to some of the larger pharmaceutical companies who feel that there is a danger that there may be some imbalance in Government support in this area. It is the Association's view that the limited amount of Government funding available should be used in the most effective way. We do agree however that the bureaucracy of the various systems be minimised.

From the view point of smaller companies schemes such as SPUR and SMART have been useful but are of limited value because only partial funding of innovative projects is available. In the early stages of development access to schemes which provide full funding for specific projects within developing companies would be of greater value. Such schemes are available in the US in the form of small business grants. Recently, in the UK, even the limited amount of money available for the existing DTI schemes has been reduced. The withdrawal of support for the Faraday initiative is one example.

Improvements to the mechanism for evaluating the proposals under all these schemes would be of value to ensure that those projects which are awarded funds are genuinely innovative.

UK Government money is available to subsidise companies which start up in areas of high unemployment, however, these areas are generally unsuitable locations for high tech, research-based companies because of the highly qualified nature of the staff and the importance of interactions with academic institutions and other communications. Currently there is little subsidising of high tech start-ups due to their location in Science Parks rather than areas of high unemployment.

3. *How effective in terms of product or process innovation and other exploitable outcomes are initiatives which encourage collaboration between industry and academia?*

The pharmaceutical industry is very well networked into the science base in the UK and has had no major problems up to now in collaborating with academic scientists. It is acknowledged however that other industry sectors may not have the same relationship with academia. Before looking at the initiatives which encourage collaboration, it may be useful to review why the pharmaceutical industry needs such collaborations, and what are the barriers to the collaboration?

(i) *Why does industry need such collaboration?*

Industry needs to play an active role in UK science both by funding and by contributing ideas to academic research programmes. It needs to be aware of the broader science outside its own research portfolio, and to be "tapped-in" to pre-competitive developments. Such collaborations help to expand the company's innovation base by conducting research often away from mainstream commercial activities. The basic research in academia underpins the more focused research carried out within industry. Collaborations allow industry to keep a watching brief on developing and perhaps competing technologies. Such projects can provide timely access to new techniques, and provide training for industrial staff. Establishing strong research collaborations helps the industry to assess and comment on centres of excellence, and to identify the most relevant recruitment centres. Industrial funding of studentships and post doctoral fellows gives industry an opportunity to assess the performance of potential recruits, and helps academic colleagues understand the rigours of industrial research and the types of jobs for which their students might be recruited. Many companies support teaching in relevant areas, and their staff hold visiting lectureships at various universities.

Collaborations with academia can also be used for rapid access to technology not available in the industrial laboratory. This type of collaboration is likely to take the form of contract rather than collaborative research and may be used to provide evidence to corroborate in-house studies, and thus support research or marketing strategies of the company.

Rapid technological advances and increasing emphasis on core business will mean that the pharmaceutical industry will rely increasingly on outside contracts to fulfil its objectives. Much of this will be with the contract sector (eg screening, tissue culture, large animal pharmacology etc) but academia will also play a role here as recognised by those universities establishing an increasing number of campus companies to meet the need.

(ii) *What are the barriers to collaboration?*

The internationally-based pharmaceutical industry has been very active in R&D in the UK for many years. The main driver for this has been, up to now, the quality of UK academia in its ability to produce good graduates for recruitment, and also the positive attitude of many academic institutions towards collaborative research. The main issue likely to affect collaboration in the longer term is the potential decline in the UK science base if Government spending on research and related activities (university equipment and infrastructure) is not increased. The money being spent is being spread too thinly and not sufficiently prioritised. Greater selectivity and a focus on excellence will be essential in the future.

Government spending on R&D has fallen by 12 per cent in the last 10 years, and by the financial year 1997–98 will be £1 billion less than in 1986. Funding of research equipment has been hit particularly hard with the 1996–97 expenditure on capital investment in universities initially being cut by £107 million, a decrease in funding of 31 per cent. The state of equipment in many UK universities does now present major problems to collaboration.

Increasing difficulties in finding well trained graduates with the right practical skills and exposure to modern equipment is also causing the industry concern. Many of these issues have been brought to the attention of the National Committee of Inquiry into Higher Education (The Dearing Review) which, it is hoped, will be able to make suitable recommendations for action.

At the specific level, other barriers to collaboration include:

Unrealistic estimation by the university (Industrial Liaison Officer and/or occasionally the academic scientist) of the worth of their discovery/proprietary technology to industry.

There is sometimes too much emphasis on "up-front money" and too little on deliverables. For collaborative research, in the future, there will need to be a change in the attitudes of some universities to ensure that collaborations are increasingly focused on objectives in terms of quality, time and value for money.

Other main barriers to collaboration include:

- the ownership of IPR
- overhead recovery
- initial HEFCE criteria for Generic Research
- bureaucracy (in some HEIs) over the signing of agreements
- problems raised by grant conditions of charities when funding within the same department as a company

(iii) *Effectiveness of initiatives which encourage collaboration between industry and academia*

As indicated above, overheads have had the potential to be a barrier if they are increased markedly without explanation or accountability. In this regard the dialogue established between industry and the Directors of Industrial Liaison in Universities through AURIL (Association of University Research and Industrial Liaison) have been very effective in helping each side to understand the other's problems. Initial DTI support to help AURIL become established was therefore very helpful.

Government initiatives have had varying success in encouraging collaboration (and stimulating innovation). Some schemes such as LINK have been effective in bringing together partners from different sectors in collaborative research projects. The LINK type schemes can provide "leverage" and tackle complex scientific issues which are slightly peripheral to many standard degree/postgraduate courses. Following its restructure to allow collaborations between a single company and one or more academic laboratories, the scheme now provides an incentive for small companies in particular to embark on research projects of a more speculative nature which they might find difficulty in justifying if they had to fund them fully from internal (venture) resources.

One of the problems with many of the European schemes directed at SMEs is the requirement for involvement of more than one company in the collaboration. This may be successful in some sectors where genuine "precompetitive research" can be defined or for example when the companies fall into different sectors and are not in direct competition. It is unlikely to work for the biomedical industry however, where even early research is generally highly competitive and companies need to ensure exclusive rights to IP arising from the collaboration in order to underpin the necessary investment for the long term and expensive drug development process.

Further investment into single company/academia collaborative schemes such as LINK would be beneficial to SMEs in particular if the proportion of funds supplied by the Government were to be increased. The Technology Foresight Initiative has catalysed a useful reflection on future needs and through the Technology Challenge Competition has stimulated some new interactions between industry and academic groups. Some in academia and industry would be concerned if research funding patterns followed too closely

the Foresight recommendations. Others feel that there needs to be a greater transfer of resources towards the research recognised as important by Foresight. Nevertheless, the apparent lack of "new" money going into the Foresight related schemes has inevitably resulted in Research Council budgets being diverted, thus possibly lessening the pool of results from other areas of innovative, curiosity driven research.

4. *Does financing need to be improved for technology-based small firms during their crucial start-up and early development phases?*

From the perspective of the technology-based small firm there is a need for improved financing. There is a particular need for seed funding for high risk ventures in the biomedical area. Many potentially exploitable ideas with significant potential to support new companies are not currently exploited because of insufficient funding to carry out the early stages of proof of principle. Although the climate has improved there is still a major gap between the initial seed idea and venture capital early stage funding. Such ideas frequently cannot raise support from research funding bodies because they are too commercial and unable to attract "venture capital" for a variety of reasons including the perceived uncertainty of the outcome.

In 1995, only four per cent of total UK venture capital funds went into early stage companies. Although the role of business angels and entrepreneurs is becoming more prominent in the UK, it is argued that much more could be done. Currently available tax incentives do not really get at the heart of the matter, and many business angels are "technology shy".

A recent initiative by the Medical Research Council is attempting to address this problem by raising a seed fund predominantly aimed at providing funds for early stage ventures arising from MRC funded research. This may also help to increase the commercial awareness of academics. Further initiatives of this sort are being set up, but more should be encouraged. An increase in successful start-ups in the biomedical industry in the UK is likely to benefit existing companies in the sector by generally increasing the interest of the larger institutional and other investors in a growing opportunity.

It has also been argued that more direct government funding for early stage companies is also needed. As mentioned above schemes for subsidising location in areas of high unemployment are effectively unavailable to small technology-based firms for R&D facilities (whereas manufacturing facilities which generally follow later in development can be located in qualifying areas) and there is therefore a need for alternative schemes to help with start-up and early development costs for R&D facilities. Again in the US many biotech companies receive very large sums from State governments for development of their facilities (One UK biotechnology company recently obtained substantial state funding towards the cost of building its facilities).

The opposing views of some larger pharmaceutical companies on this matter however do need to be considered. The pharmaceutical industry has argued that policies that seek to promote the interests and capabilities of smaller companies, but *which act to the detriment* of those larger companies with proven track records for successful innovation and commercial exploitation should not be supported. SMEs are not the sole means of converting research into commercial innovation. Although it does not apply to the healthcare sector where innovative technology competent smaller companies do prosper, and will develop further in an improved venture capital and financial environment, the view has also been challenged that direct governmental action, through the provision of subsidies etc, will really stimulate many SMEs into changing their attitudes to the carrying out of innovative R&D.

5. *What other support systems could be introduced to ensure that the maximum advantage is taken of innovative ideas that originate with individuals or, for example, in academia?*

One of the recommendations arising from the Health and Life Sciences report of the Technology Foresight Initiative was the need for Technology Incubators.

Technology incubators which provide access to laboratory facilities and equipment at moderate cost can provide a very valuable cost saving to companies in their early stages. This allows for the seed funding to be focused on R&D rather than on buildings and equipment. The MRC Collaborative Centre in Mill Hill has been successful in this respect (it provided start-up facilities for the biotechnology company Prolifix) and based on its success another Collaborative Centre is being set up in Edinburgh. A similar facility is shortly to be opened at Manchester University. The development of incubators in other areas should be encouraged.

There is a major problem concerning the lack of laboratory space which could be leased, preventing the turning of the concept of technology incubators into positive action. The Association is aware of a number of academic groups who are struggling to find a way in which to get started, and were they able to lease laboratory space, would have a good chance of establishing a new innovative enterprise. It is difficult for industry, at present, to support this technology incubator initiative directly—there being no immediate advantage in supporting pre-competitive activity. Nevertheless these will be the breeding grounds for the technologies of the future.

6. *Is there institutional inertia towards the funding of technology-based small companies? If so, to what extent may this be due to financiers' unfamiliarity with science and technology concepts and what should be done to address this?*

Yes, there is some institutional inertia towards the funding of technology based small companies, particularly in the healthcare and biosciences sectors. Much of this could be due to the lack of understanding of many of the financiers in the process of R&D in the development of new therapeutic products, in particular the timescales needed to take a product from research to the market place.

There is a sophisticated UK venture capital community targeted at high investments, although the bulk of their biotechnology funds are invested in the US. This is also related to the relative availability of exit routes in the US which provide higher returns on risk capital.

Although the UK has led the way in Europe in terms of funding new bioscience companies, a number of obstacles remain. Considerable sums of capital are needed to fund early stage bioscience business through to profitability. The growth of publicly quoted companies in the UK is a welcome trend and the enhancement of their valuations through attracting new investors to the sector has helped to put the British industry firmly on the map. However, there remains a continued inadequacy of UK investment into the area of high risk start-up phase of new businesses. The long period of inherent instability which public companies must endure before they become successful businesses also remains a substantial hurdle.

The recent success of the Alternative Investment Market and the establishment of EASDAQ, a European version of the successful NASDAQ screen-traded electronic market, may go some way towards helping the creation of a pool of investment funds for bioscience start-ups. Another possible way around the funding problem which is being successfully used by a number of small companies is to remain principally research houses selling ideas on to the established companies for them to develop into marketable products. With its large successful pharmaceutical companies, Britain is well placed to take advantage of this opportunity to strengthen both small and large companies alike.

Any measures which encourage the growth of the new biosciences industry, such as the formation of more start-ups, will in time lead to the development of a specialist analyst community (rather than a generalist community) which will help to address this issue. Also, as has been pointed out in other submissions to this inquiry, a lack of familiarity with science and technology concepts is not restricted to the financiers. Many within the Government responsible for the introduction of policies affecting the science base appear to have not always fully understood the science and technology process.

7. *The Committee recommended tax credits for research and development in our previous enquiry. Would this still be an effective way of fostering innovation and how should they be introduced to ensure that they are roughly cost-neutral?*

Tax credits would be an effective way of fostering innovation within the new biosciences industries. A BIA proposal on this matter was endorsed by the Association and submitted some time ago to the Treasury, but was not taken up. Such bioscience companies have very long lead times with high R&D spending. The use of the tax system to compensate for the tax losses built up in this time to assist with cash flow would be of benefit. Tax credits should be applied to all income, and not just sales income. Such credits could be usefully invested in incubator units, start-up companies, collaborative research with academia and larger companies or clinical research projects.

It is accepted however that it would be difficult to ensure that such initiatives would always be cost-neutral.

8. *How has the Technology Foresight Exercise influenced the availability of development funds for innovative ideas that were not given short-term high priority status?*

Working closely with the Health and Life Sciences Panel of the Technology Foresight initiative, the Association has promoted the programme to its member companies from the start of the exercise.

We do consider that much of the successes of the Foresight exercise will be in the longer term and will build on the increasing liaison that is being established between the academic community and industry (both SMEs and larger companies).

Much of the focus within the pharmaceutical industry has, up to now, been within the R&D functions, areas where there already is a high level of networking and partnership between companies and the academic community. This side of the industry is already heavily involved in long-term foresight type initiatives, and in many ways the pharmaceutical industry may be the least likely to benefit from further involvement.

There has been some concern raised that the only specific influence of the Foresight exercise to date has been some short-term initiatives such as the Foresight Challenge competition. There have however been some other achievements. On the Health & Life Sciences side we have seen a number of developments stimulated by Foresight including:

— Three new Foresight responsive LINK programmes (Integrated Approach to Healthy Ageing, Genetic and Environmental Interactions in Health, Analytical Biotechnology).

— Development of a new Government initiative on the quality of life "EQUAL".

— The cross Government department "Crusade for Biotechnology", co-ordinated by the DTI.

— A major review of the chemistry/biology interface, and the barriers to co-operation in this area.

Work is still in progress on addressing problems concerned with the infrastructure of universities, and facilitating developments in integrative biology, neuroscience and the establishment of a network to maximise the benefits of health informatics. On the chemicals side, Foresight has led to an assessment of the UK's strengths in catalysis, which will be built on. There is no real evidence however, that other industry sectors, especially those without investments already in R&D, have increased their support for innovation as a result of the Foresight exercise. It is those areas that will need to be targeted as Foresight enters its next phase. These sectors will need encouragement and support to help them build effective partnership with academia.

9. *Has the tax relief introduced in 1992–93 for individuals' expenditure on vocational training had any impact on the status of continuing professional development, in particular for employees in small firms?*

The pharmaceutical industry is a notable UK example of a successful high-technology and research intensive sector. Pharmaceutical companies are fully aware that they depend on the skill, flair and innovation of their workforce and to this end the industry, through ABPI, has for many years taken a leading role in education and training policy formulation and direction and in the development of training standards and programmes.

It is the Association's understanding that the introduction of tax relief for individual's expenditure on vocational training has had little or no impact on the status of continuous professional development in small firms. We are not aware of the promotion of these changes at the time, so it is possible that many firms and employees were unaware of the introduction of the tax relief.

The attitude to training either seems to be supportive or negative. If it is the former, the company will pay for employees' training and tax relief will not be an issue. If the attitude is negative, then there will be little encouragement for employees to undertake their own development, and personal time to spend on studies will be of more importance than the money.

Examination of witnesses

DR TREVOR JONES, Director General, ABPI, DR KEITH MCCULLAGH, Chief Executive, British Biotech plc, DR SARAH ECCLES, Business Development and Licensing Manager, Therexsys, and DR MICHAEL ELVES, Director of Scientific and Educational Affairs, Glaxo Wellcome, were called in and examined.

Chairman

227. Good morning, Dr Jones.

(*Dr Jones*) Thank you, my Lord Chairman. As some of you know, I was formerly Research and Development Director of Wellcome Laboratories. Sarah Eccles is from Therexsys, an SME; Michael Elves is from Glaxo Wellcome, involved with science policy; and Dr Keith McCullagh is the Chief Executive of British Biotech, which was an SME but I believe now is a developing company in its own right. This industry is a very good demonstration of the ability in this country to take innovative ideas from the laboratories of industry or from academia and translate them into commercial and therapeutic benefit. The fact is, of course, this process does take a rather long time. Traditionally, it takes 12 years or more to bring a product to market and therefore the long-term stability of the environment in which we conduct that transfer is a really central point of the messages. You will have seen in the submission references to the need for balancing investments in this area between the major global players that are based in this country and the innovative new small companies. To us, it is not an either/or situation; both are necessary and we need a proper balance between funding and other forms of encouragement. It is clear to us that a number of schemes that are or have been available from the government departments are terribly complex in their administration, in their terms and conditions and their availability, and one thing we would strongly want to see in any future activity is some simplification of that both in procedure and in flexibility. The financing of this activity in this industry is very important not least in the translation of research ideas to these SMEs and the start-up companies. We feel that there has not been a very strong environment for the initial funding of these companies. This is changing as more venture capital opportunities come, but we feel there are other measures—some of them you have seen before—that could come into play there, not least the use of tax credits as a component of small companies and Dr McCullagh will be able to answer some of your points in that area. In summary, the pharmaceutical industry is investing considerable financial and human resource not just in invention but innovation in the roundest sense of the word, not just in discovering new products but in process technology as well and we want to make sure that all these aspects are covered. We are investing not only "in-house" but significantly in universities and in start-up companies and in collaborative deals. We are concerned that if the decline that we see in the science base were to continue it could compromise our position to do that in this country. I do not

Chairman *contd.*]

believe it would inhibit the global industry from doing the research development, it is just that it would do it elsewhere; it would move to where that was more attractive. We have made the case in the submission for maintaining the science base and strengthening it. We like incubators, we think they are a very good idea but we do not see incubators as SMEs. As I said at the beginning, unlike many industries, this is a good example of how to translate good innovative science into practice over the long term. To do that we do need the intellectual property environment which allows us to protect the inventions commercially, not least the problems we are going to face if we are not successful in the European Biotech Directive that is going through the European Parliament now. 228. What proportion of pharmaceutical research is conducted in universities and the wider research community rather than in-house? To what extent are "known" players in the field relied upon? What is then perceived to be the main role of the university sector in all of this? You must have a clear idea.

(*Dr Elves*) Glaxo Wellcome relies to an increasing extent on university research. It is very difficult for us to quantify at any one time what percentage of our research budget is spent with the universities as partners and collaborators, but a rough estimate at present is probably around about five per cent. From the United Kingdom side of the company we spend round about £10 million a year directly with higher education institutions on basic and underpinning research out of a total budget probably in the UK of about £100 million for all the research activities. We are excluding from this consideration clinical trials which we do not regard as on the research side but on the development side. I think the university system is playing an increasingly important part in our drug discovery activities and we think that will continue. The reason for this is that the major explosions we have experienced in the last decade or so in the fields of cellular and molecular biologies and the new genetics in particular are opening up new understandings for us to develop ways to discover new therapeutic entities to treat important human diseases in a way that addresses, very directly, the cause of the disease and the mechanism which underlies it. We cannot do that ourselves. We rely very heavily now on our colleagues in academia to do a lot of the really fundamental, and underpinning, research for us. And the collaboration programmes that we and other companies put in place are very much designed on the basis of partnership and the academic researchers are with us (as I think we said in the Glaxo Wellcome submission) as part of the continuum from the acquisition of knowledge to its application for discovery of new medicines. The barriers between us are now largely removed, or at least minimised. Where do we do our research with universities? Clearly we go to those centres where there is research excellence in areas that are relevant to our own interests, and that can add value to our own in-house activities. We are also global companies in many cases and, therefore, we are not confined to looking to the United Kingdom's universities to find this expertise; and we are increasingly having to look abroad. But, having said that, Glaxo Wellcome for example has collaborations with about 59 to 60 university establishments in the UK. Clearly we pick those people who are best able to meet our needs. The main criterion is science excellence and relevance to our own programmes.

(*Dr Jones*) The Glaxo balance between in-house and universities is probably typical of major companies, i.e. five to ten per cent excluding clinical and if you include clinical then ten to 15 per cent would probably be about right for the main companies.

Lord Kirkwood

229. If patent rights for innovations resulting from university research were awarded to the principal investigator in the project, what do you think the effect would be of this, for instance on the generation of spin-off companies and on industry/academia collaborations?

(*Dr Eccles*) Our feeling is that this would not have a very great effect on the stimulation of new companies or on industry/academia collaborations. Certainly, there need to be incentives for innovation and most universities have schemes whereby the inventors do benefit from their innovations and it is important that is encouraged. However, individual inventors will rarely have access to adequate funds to finance patent filings. What I think is important in this area is that universities and other academic organisations are encouraged to provide and get support in providing technology transfer advice for inventors. Many universities have very few resources to do this and I think that concentrating on increasing the funds available for the technology transfer process, to ensure that funds are available to secure early patent protection, would be beneficial rather than focusing on who owns the patent rights. Keeping incentives for the inventor through any exploitation that takes place of their work is also important. Clearly having strong patents is extremely important to the industry. We do need to ensure, for example through the Directive which is currently going through the European Parliament, that the effectiveness of the patent system is not diminished. The Directive as it is drafted at the moment is broadly acceptable to the pharmaceutical and bio-technology industries, but if the drafting is changed it is quite probable that there will be an effect on the strength of the patent system to the detriment of industry in Europe as compared with patents, for example, with the patent system operating in the United States, to the advantage of US industry.

Chairman

230. Could you just spell that out in a little bit more detail, please?

(*Dr Eccles*) The Directive addresses issues of patenting inventions in biotechnology, for example patents on inventions based on genes, defining what use can be made of the knowledge derived from the discovery of a gene in the development of products and which aspects of this process are patentable. There has been a large amount of debate about the issues surrounding patents in biotechnology,

Chairman *contd.*]

whether or not it should be possible to patent genes because of their association with "life" and the ethical issues have to some extent diverted the discussion. Essentially the Directive supports the granting of patents on genes where inventions have been made, that is where there are real inventions involved and that these should be judged as patents. This is the key to the development of products based on inventions in biotechnology. If the wording of the Directive is amended the effect of that is likely to be diminished. At the moment the European Patent Office is granting patents on inventions in biotechnology and it is important for the industry that it can continue to get those patents to protect its investment in developing those inventions.

Lord Kirkwood

231. One of the problems that universities have with patenting is that it is really the first stage in the process. If they patent something and cannot defend it because it becomes very expensive, it is hardly worth taking out the patent in the first place. Are there good solutions to those problems because universities obviously cannot afford to follow the whole thing right through to the end otherwise they would have no money for other purposes such as teaching?

(*Dr Jones*) It is a complex area. The fundamental issue to which my colleague referred is whether one can patent a piece of biotechnology. The act of discovery and the act of invention are very different and we believe the Directive is very clear on that matter. The question you referred to is, at what point should the patent be applied for and who should you collaborate with in order to ensure that it is broad enough and safe enough to have the cover required for commercial exploitation. I think in that context the concept of a single principal investigator being the complete owner of a patent would not be necessarily appropriate. In my own experience, for example, at the University of Strathclyde we had a very good collaboration at my time at Wellcome in developing a drug called Tracrium, where the inventor (one of the professors), the university and the company all benefited by getting the "mix" right about who was going to do some of the expansion of the basic patent, who was going to negotiate the terms and conditions of the patent right and how the industry could ensure it was covering its economic needs. I feel that is very important in getting that balance between those players right.

(*Dr McCullagh*) You are right that it is the next stage, the prosecution of the patent around the world to establish effective patent protection, in a variety of territories, which then becomes an expensive process. At the moment many university technology transfer organisations cannot afford to progress this. Neither can, in most cases, the inventor who is an academic. So, giving the inventor more responsibility would not accomplish the end. However, I think this opens up the whole issue of the function of universities. As well as education and research I think that universities ought to have a responsibility for seeing that society benefits from that research, and that means a role in wealth creation in the community. In order to achieve the benefits to society of the research going on in universities, it is very important that the patents are prosecuted and then applied. I think that means that in our funding in universities we must give priority to funding technology transfer. The industrial liaison office is a much more important part of the university system than it has been hitherto.

Viscount Caldecote

232. You mentioned the importance you attach to a strong science base in support of your programmes. Could you give some idea, as far the origin of ideas is concern, as to what sort of proportion come from your own people or from universities?

(*Dr Jones*) To my mind there is no simple solution to that. I have seen brilliant ideas emerge both in the industrial laboratories and in academia. The industry has its own collection of Nobel Laureates whose ideas are from their laboratories, if that be one judgment of innovation. To my mind the scientific community in a particular field tends to work together, the people in academia and industry who have a common interest in a mechanism or some fundamental aberration of the biology know each other and work best together. The single act which then becomes the invention is not always something you can say is academic or industrial. What is important is to create an environment that such innovation and collaboration flourishes in. Some of it is clustering, some of it is increasing funding in the right areas of support, but much of it is the human nature of interaction as well rather than just the structure.

(*Dr Elves*) What Trevor Jones has said is absolutely correct. I think our working with and funding of, researchers in universities is on a very different basis to the sort of funding that might occur through a charity or through a Research Council. We always make it an overriding principle of our funding that we enter into effective collaborative partnerships with our academic colleagues so that the company scientists and the academic scientists meet regularly; they often share ideas, bounce ideas off each other and under those circumstances you have got an "incubator" that generates the ideas and it is often extremely difficult to pin down exactly where that idea came from. In the case of Glaxo-Wellcome, for instance, our collaborative arrangements invariably put the intellectual property rights with the company because we believe, first, that we have got the intellectual property/legal skills to get the best possible protection for anything that arises out of the collaboration. Secondly, we are in the best position to cover the costs of prosecuting and, if necessary, defending that patent against infringement worldwide. Most universities are not in that position. Having said that, our relationship is not an ownership relationship in reality, it is more of a "trust" relationship. We hold the intellectual property jointly for both of us, and the university department would benefit from any exploitation by us through royalty payments. If we do not exploit the invention then we assign patents lock, stock and barrel to the university to do as they want with. The

Viscount Caldecote *contd.*]

overriding principle must be that we should exploit new information as far as possible and we must not put barriers in the way of that. However, to get it in perspective, 99 per cent of our collaborative programmes do not result in patentable inventions. A very, very, small percentage of them do.

Lord Dainton

233. Your industry is really a model to us all in its best behaviour and its relationships with universities. It has really been very fruitful. I suppose a good part of that is due to the great similarity to the kind of activity that goes on in research in industry and in universities in this field in terms of intellectual content and resources required. Looking to the future and seeing what you have written, I see quite a lot of criticisms of the present situation which give me a sense of foreboding about the future and perhaps we could touch on those now. You say, for example, that some of the forms of funding by the Higher Education Funding Council are unhelpful. You refer to GR funding. I think we would like to know about that. Also, you say in several places that the Government is reluctant to fund "near market" research and that it ought to be a little bit more forthcoming I take is the implication. You further go on to say, which is really quite alarming, that there is a decline in the infrastructure of the university research base. I certainly think that you as a global company, I am now thinking of Glaxo Wellcome, will find whatever academic base you can which suits your needs best wherever it is. I noted with interest, because I have an interest in that part of the world, your great investment in the National University of Singapore and I wonder whether, looking to the future, you will tend to go more overseas because of this declining base in Britain, if it is true, and what you think should be done to improve that base in Britain?

(*Dr Elves*) If we can take the first topic first and that is government schemes that are not necessarily helpful to encouraging collaborative relationships between academia and industry. The GR funding mechanism that the Higher Education Funding Council of England created a few years back was designed by them to encourage academic/industry links. However, they failed to consult either academia or industry about the effect of what they were proposing. It was inherent in that scheme that the intellectual property arising out of the collaboration should be unencumbered and should belong to the university. That means that for the pharmaceutical industry, where ownership and management of IPR is absolutely central to the value of the information, most of our collaborators were unable to benefit from that GR element of funding. That element of funding was not enormous, it was in the region of about £20 million, but the ripples it caused with our collaborators and the disquiet that we had to face from them was out of all proportion.

234. Was it an edict actually preventing universities from doing the sensible thing?

(*Dr Elves*) It was a "dictat" which said that if they wanted an element of the GR funding to go to their university or departments they had first of all to be working with industry but they had not got to give the intellectual property to the company, and that was a barrier to us. We have overcome it because the small amount of money that GR funding represented was not a real barrier, but there was a cultural barrier there that we had been working to break down. The "GR" scheme was counter-productive to what we were trying to do. The other complaint we have got is in the current vogue for Challenge funding for particularly infrastructure items where a recent government scheme such as the Technology Foresight Challenge Fund require the private sector to put matching funds in in order for the academic to stand a chance of winning an award through the scheme. We were never consulted beforehand about these schemes and the first we knew about some of them was when we started getting applications from academic colleagues to partner them in such applications. We had to turn the majority of them down, and that again sours the relationships that were pretty good. We have had to re-build that relationship back again. So we would suggest, first of all, that we are consulted before schemes are launched like this that affect us pretty seriously. Secondly, they take no account, for instance, of our need to budget, because very often these schemes are announced with very short application times available. The other problem that we have had from time to time, for instance, with LINK is a fluctuation between favouring multi-company arrangements, where large and small companies and academia all work together which in our view is a totally ideal situation, because it brings about the greatest interests, and then the rules will change so that it has got to be a single company, particularly an SME. We would like in these schemes, please, consistency, and rules that are actually "operateable" and do not go counter to what the scheme is intended to achieve.

235. One of the ways in which that kind of difficulty did not arise in the old University Grants Committee days was the powerful representation of very distinguished industrialists as part of the committee. That does not seem to exist at present in the HEFCs.

(*Dr Elves*) There is industrial representation obviously in the funding councils. It is not as strong as it used to be, but some of the challenge funds come out from OST when often we are not represented.

236. Does it strike you as a good thing that the OST has therefore moved into DTI? In principle it might look from your point of view to be favourable, but is that the case?

(*Dr Elves*) We do not see any down side to OST being in DTI, and I do not think it has really had that much of a detrimental effect on us.

237. I was wondering if there were benefits.

(*Dr Elves*) There probably are, but they are imperceptible in that we almost take them for granted. We work with OST quite well and always did.

(*Dr Jones*) I think that is the key point. We probably would have preferred the OST to stay where it was because it had the more direct ear of the Cabinet, but its movement to DTI has happened and, frankly, seeing it move back or forwards does not

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seem to me to be a productive way forward. Could I address the other very significant point that we raised and you raise concerning the fabric of the university structure and the debate of "UK verses somewhere else" as to where one should do research. It is evident to the scientific community and others that if you walk around other universities, other than some well-endowed universities, the physical fabric of our university laboratories as well as the equipment is really declining significantly. In our paper we have given some facts of the actual decline over the years in funding that we believe has led to some of that. In the last ten years, some 12 per cent less is spent on R&D, and the financial year 1997/98 will be £1 billion less than 1996. I refer you to those points. The fact is that we still feel that Britain has amongst its scientific community some of the best biomedical scientists in the world. It has established that over many years. And if we see that continue to decline we fear that it would be a problem to maintain that kind of infrastructure necessary for our pharmaceutical R&D. Behind that, of course, is the determination that the quality of graduates that comes from the system must also be maintained and I know you, my Lord, over many years have been a great proponent of Britain's quality of scientific output. We are addressing those issues, in multi-department talks between the industry and government departments as well as through the Dearing Review. If I return to the issue of the fabric and the equipment in our universities, it seems to us that the funding has to be put back into that system in a way that assures at least the chance that we can continue to maintain and hopefully increase this excellence. Just throwing money at science is not the answer and I think there is going to have to be some selectivity as to where those funds, if they were available, would be put. To my mind one of the attractions of inward investment in this country is the quality of our long-term success in science and in pharmaceuticals and that is evidenced by the investment that is continuing from Japanese companies and American companies, Pfizer expanding at Sandwich, we see Yamanouchi increasing their investment at Oxford and so on. It must be a concern that we see this maintained. As I said earlier, the global drug companies will continue to invest in R&D but they will simply do it somewhere else and we should not let that happen. We simply have to try and preserve the quality we have here in the UK.

(*Dr Elves*) Can I give a very positive example of what we actually see in our university system and it is not only about lack of modern equipment. The University of Cambridge's chemistry department, which I think we all believe to be one of the jewels in our "chemistry crown" in the UK, has got state-of-the-art crystallography equipment less than three years old. That is extremely good for a British university. But is sitting in a building that was built in the 1950s. It is not in air conditioned rooms; there is very little temperature control; there is very little opportunity to keep dust to a minimum. The environment has got to influence the performance of the equipment, and therefore the performance of our academic colleagues, and at the end of the day it is going to affect the life-span of the kit. That is something we often see.

238. The real problem here has been the reduction in capital funding from the Government on the science and technology side. But given that is likely to continue, let us make that as an assumption, the question then comes down to how can the situation be improved. I would very much like to know your views on this. It may be the case, for example, of a concentration of resources of high quality in an area which would be available to a lot of academics from different institutions. What are your views on that?

(*Dr McCullagh*) I am very worried by the assumption in the first place. I think all of us throughout the whole industry, whether we come from large or small companies, are very concerned about the deteriorating science base in this country. It is fundamental to Britain's competitiveness in the world, in the next century, that science funding is increased, not decreased. This includes funding for research, funding for higher education, for training the scientist as well as funding for capital investment. The current decline is eroding that competitive base in a major way. If the current decline continues then the only way one can see a way forward is to concentrate on centres of excellence. This should not be too restrictive, ie just Cambridge, Oxford, London and Edinburgh. We need a spread of investment across the science base. So I think we feel two things: one, that the science base is declining and it is currently inadequate to support a competitive British industry and, secondly, that it is spread too thinly in any case. So I think both the situations should be addressed.

239. May I just take you up on one point. The difficulty about that concentration, and it has been a subject for 30 years, is that the seedcorn can arise in any place and the problem is how to avoid missing a lot of that good quality.

(*Dr McCullagh*) I entirely agree with you, and that is very worrying when one starts to look at selectivity in terms of building centres of excellence. There could be a problem for example in that a centre of excellence in neurosciences based around the department of, shall we say, pharmacology at Oxford, could miss a very exciting new research programme going on at Nottingham, which does not get funded because it is not in the right place. So by funding excellence one has to go back to the basic principle, you fund on scientific merit wherever it may be, but I have to say that is already being done. The current funding in all voluntary organisations, the MRC and the BBSRC and others all have many more applications they would like to fund than they have the ability to do so.

240. There is a difficulty about this too, I am afraid. In the University of Oxford, which I claim to know reasonably well, the internal arrangements for working together are not of the highest, shall we put that way. Some universities have taken the ball and run with it. You referred to clusters in your earlier evidence and I could mention universities where molecular recognition, which lies at the heart of some of these things, has been recognised and departments have been brought together to create research centres. Do you think that is a sensible way forward?

(*Dr Elves*) I think when we are talking about centres of excellence we need to be broad minded

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about what we are talking about, and we should not confine our thinking to a centre in the geographical sense. I think we must find new mechanisms to harness the science that we have got, and the intellectual capital that we have got, in our UK HEIs. Therefore, the concept of a "virtual" centre of excellence has got a lot to commend it. It can lever a maximum value out of high-class equipment by academic departments sharing resources, sharing ideas, coming together. Geography is not, or should not, be a problem any more. We have excellent IT and communication technologies available, and occasionally we have trains that work as well, so distance does not become an issue any more.

241. The traffic in ideas is perfect, but from the point of actual hands-on experimentation it is not.

(*Dr Elves*) We need to establish that. There are centres that I know of certainly in the northwest where university departments in Liverpool are collaborating with departments in Manchester at a hands-on level. I do not think we should rule any particular arrangement out, but what we should have is Research Assessment Exercises that do not work against collaboration. Currently the RAEs are focused on making academic departments stand on their own, competitively. We need to have a research assessment facility that allows us to recognise and reward collaborative effort because in modern science, it is all about collaboration.

242. Just last night I was at a meeting with Lord Tombs in which it was repeatedly stated that the quality of the British science base remained extremely high and so on and so forth and that an external observer looking at the university system, would maintain that there had been an improvement over the last four years from 1992-1996. I must say from my standpoint, going overseas and looking, the views which are expressed overseas and also the assessment by any pseudo quantitative measure, that is not the position but nobody here seems to recognise it. Are we imagining our quality?

(*Dr Jones*) The general feeling from the industry is this: Britain still has some truly world-class centres of bio-medical expertise but others are catching us up fast. That is good for the industry because it provides more talent that we can use wherever it is, but obviously with the base that we have in the UK we would like to see that preserved. To my mind the point you raise about collaboration within an institute or within a university is an interesting one. Research, as you know, is a hugely competitive activity amongst the scientists concerned and that happens in companies as much as it does in universities. Simply grouping people together and saying "collaborate" is not the answer, but creating the environment in which it is easy to collaborate and the interface between university and academia and industry is lessened is the way forward.

Viscount Caldecote

243. Overall, would you say that this lack of supply of well trained, well-educated scientists is a limiting factor in innovation or are you just afraid that it will be in the future because of your view of the declining science base?

(*Dr Elves*) It is actually, my Lord Chairman, starting to be an issue. The science graduates that we now see coming through university degree courses are intellectually very good, they are the best and we often seek the best. Their state of knowledge of their subject is usually first rate. The deficiency that we see in them regularly now is that they lack the practical skills to practice their art. The practical element of degree training has now diminished almost to a point of uselessness. Most students will come to us having done a project. But often many do not understand why they did the project or what it was really about, they cannot really discuss it; but they lack the really fundamental laboratory skills like how to make solutions up, or how to find their way around an animal if they are pharmacologists, because the present expense of providing practical training is getting to be prohibitive and again it comes back to the money for the infrastructure. Secondly, the curriculum is becoming crowded with knowledge and the time pressure on courses is becoming such that practical work is diminishing. As a result of this, companies have got to spend a significant proportion of the first year of any new graduate's life in work training them in areas which were once covered by training given during their degree studies as a matter of course. That is a worry for us. As an industry as a whole we have been proactive in trying to provide corrective measures. Most of our companies now have industrial trainee schemes which came out of, what we considered to be excellent sandwich courses. In Glaxo Wellcome now we have about 180 industrial trainees drawn from universities of all sorts, not only from the former polytechnic sector. They come to us for a year, they become a member of the staff for a year, they get to know how to work in a laboratory very thoroughly, they get to know what industry is about and what real life is about. Our academic colleagues, when they receive them back for the final year, say that these are not the people that they sent out in the first place. We feel that is a very valuable contribution to plugging the gap. Some of us have also been supporters of the Master of Research (MRes) Degree concept and have encouraged that development, have funded students and have also provided staff members to go and talk to those students. The MRes pilots are showing that the courses have enhanced the technical skills of that particular cadre of research people. Finally, we support a large number of PhD students either through co-operative award schemes, or fully funded by companies themselves. So I think we are doing what we can to plug the gap, but there is quite a way to go, I think.

Lord Tombs

244. There seem to be two contributors to your dissatisfaction with the quality of graduates you are now getting. One is the equipment base which we have talked about a bit and that is not going to be solved on a universal basis, it will be solved in a concentrated basis either in university centres or in companies and with familiarity being given by transfer. The second which I find more disquieting is the congestion in the curriculum. Not a lot of

Lord Tombs *contd.*]

industries have a very proactive role in curriculum formation, they meet universities and discuss what it is they really want. Does ABPI do that or do their member companies do that and, if so, with what success?

(*Dr Jones*) It is variable depending upon the nature of the course and the university. To my certain knowledge a number of us are involved in just that exercise, for example whether it be looking at the structure of a single course e.g. pharmacology, whether it be looking at, as at Nottingham, the whole basis of the pharmacy degree course. I believe it is important, however, that we do not try to turn universities into industry training shops and we do not try to turn their research endeavour solely into drug hunting.

Lord Currie of Marylebone

245. What success has there been for companies who have set up their own venture capital subsidiaries and what is the typical size of investment that is thought worthwhile in doing that?

(*Dr Jones*) The environment for venture capital investment by pharmaceutical companies is one that is growing in the UK. We are seeing evidence that British companies as well as those from North America and Continental Europe are using this as a mechanism to get close to areas of interest without necessarily engaging individual SMEs in contract research. So it is a good use of funds. It depends on the size of the company's financial reserve as to what they consider to be reasonable. Certainly, I have seen sums of up to £50 million considered to be a good amount of seedcorn to invest in such endeavours. Much depends on whether you feel that the activity you invest in fits the research you are currently doing or whether it is an activity you see as important to provide the infrastructure that gives rise to new ideas. This brings with it the whole question what incentives are there to maintain new "spin out" companies.

(*Dr McCullagh*) If I can just pick up a general issue of funding to start up new enterprises, which in the field of bioscience and biomedicine, offers I think a tremendously golden future opportunity for this country. There is no question that the science base should lead to the emergence of a very strong bioscience industry, involving SMEs, as well as the more established large pharmaceutical companies we have at present. That is happening, but it is happening at a rate that is about ten years behind, and perhaps at the moment, a tenth of the size of what is happening in the USA. If you take the whole of Europe, there are about one tenth the number of public bioscience companies in Europe that there are in the United States. Part of the barrier we are talking about to innovation, as it represents the entrepreneurial growth of new companies, concerns the funds available for the start-up phase, the seedcorn financing. Your question about how much of this could come from companies, and does come from companies, is a good one because large companies are encouraging this whole area. There is no question that it is in the interests of large as well as smaller companies that there should be a broad entrepreneurial base in this country. I do not think however that the amount of money that corporate venturing represents is sufficient, although it is a very useful credibility point, around which other venture capitalists could focus. If a pharmaceutical company makes the investment, it usually has already evaluated the science rather thoroughly and it builds confidence in the other venture capitalists. I have to declare an interest here. British Biotech, which was a start up ten years ago in 1986, received in fact an investment from SmithKline Beechham and it was very helpful at the time. I also have just stepped down from the Chairmanship of the UK's Bio-Industry Association which was strengthened and enlarged some three years ago, in order to try to foster the growth and development of a greater number of small new start-up companies in bioscience. It has been remarkably successful. However, some of the initiatives that the Bio-Industry Association has promulgated have not been implemented. One of the most important ones was our discussions with the DTI and the Treasury in favour of some taxation incentive, both for the start-up phase and for the growing company phase. One of them, which you have asked a question about, is what is the current status of the tax credit proposal. Some two years ago BIA, supported by the CBI and ABPI proposed that companies, that spend large amounts of time and money doing research and development on products that have a long gestation period before they come to market, and therefore declare losses on their P&L account, should be able to translate those losses. Instead of doing this into some future tax credit, when their products come on to the market and make profits, they should be able to exchange those accumulative tax losses for a current year tax credit. We still think that is a very good idea. The idea was that R&D expenditure could contribute to a current year credit and the company would forego the cumulative credit, which it eventually would recover when it is in profit. It perhaps should be at a different rate from the cumulative tax credit, a lower rate, but, nevertheless, the company should be able to exchange their investment and be encouraged to leverage the investment that they are making, by getting some benefit from the tax system. We proposed in fact, that the credit be implemented by being offset against the PAYE National Insurance contributions that companies collect and provide to the Inland Revenue in any case. It would therefore be capped by that, so there would be no net flow of money from the Treasury. Unfortunately, although this approach was supported by the DTI quite strongly, it was not found acceptable by the Treasury. We still think that it would be a good idea. That is but one example of a fiscal stimulus to investment. There are others. For example, one could easily envisage a scheme which gave some Income Tax relief for investments into high-tech companies into a particular sector, if you wanted to stimulate that sector. Since this is a sector that requires stimulation, requires large scale investment, it seems that would be another way of doing it. One could also give capital gains tax relief on investment into high-tech companies for a qualifying period and so on. We believe there is a great scope for further discussions with the Treasury and the DTI and the Department

Lord Currie of Marylebone *contd.*]

of Health about how fiscal incentives could help funds flow into the industry.

(*Dr Eccles*) Dr Jones has mentioned before the concept of technology incubators. Speaking as someone from a small company which was founded on intellectual property which came directly from the science base in order to exploit that intellectual property, one of the issues we face is the raising of funding for the initial premises of the company, that is the amount of money that companies like us have to invest in building facilities and equipping laboratories. The availability of more technology incubators for the early stages of the company would be of enormous advantage. Although there are schemes on a nationwide basis where certain areas can attract funding for infrastructure, those tend not to be the areas in which technology based companies, biotechnology companies for example, are likely to be able to site their premises, because they do need to be in close contact with academic collaborators and those tend not to be located in areas of high unemployment where one can get development-type funding. So there is a need to look at what other mechanisms can be used to support funding for infrastructure, and technology incubators is certainly one of them.

Chairman

246. If we were Americans we would think the idea we were not in close contact with everybody in the United Kingdom was an impossible concept, because they think what an appallingly crowded and close contact place this is. Anyway, we have had a very good discussion. Is there anything you think we have missed which we ought to have picked up?

(*Dr Jones*) I would emphasise again we need long-term stability, and we need to support the science base to ensure that it does not decline further. We believe Britain is a great place to carry out our kind of research and we need to continue to ensure that intellectual property rights are protected in a manner that provides a good balance between inventor and company.

247. Thank you very much for agreeing to this cross-examination and for your part in it. We have enjoyed it and we are certainly much better informed now than when we began.

(*Dr Jones*) Thank you for giving us the time.

WEDNESDAY 5 FEBRUARY 1997

Present:

Caldecote, V.
Cuckney, L.
Currie of Marylebone, L.
Dainton, L.
Dixon-Smith, L.
Flowers, L.
Hogg, B. (Chairman)
Kirkwood, L.
Tombs, L.
Winston, L.

Memorandum by the Engineering Council

EXECUTIVE SUMMARY

In this composite response from the Engineering Council's industry affiliates, some of them world class manufacturing companies and others SMEs, a consistent picture of the "innovation chain" emerged.

In essence, there is no shortage of exploitable innovative ideas from either the UK's strong indigenous science and technology base or, indeed, from the rest of the world. Government initiatives designed to stimulate innovation are also broadly effective, but could nevertheless be improved.

The UK's perceived weakness lies in its ability to identify the right idea and convert it into a business opportunity. This calls for more emphasis on knowledge (of markets, needs and competitors), business skills and marketing. Our response maps out some positive suggestions towards reinforcing this phase of the innovation-exploitation process, noting that large companies and SMEs have different needs.

1. *What is the current state of innovation in the United Kingdom?*

(a) The state of innovation varies from industry to industry. The construction industry finds innovation difficult, for example, because it operates within a variable, unstable and cost-driven market with short-term relationships. In many other areas of engineering and technology, particularly those which are highly competitive on a global basis, innovation is:

(1) "Alive and kicking; the UK possesses enormous talent for lateral thinking and idea origination." (Black & Decker).

(2) "Highly innovative with great strengths in our Universities." (Rolls Royce).

(3) "There are many good examples of successful innovation." (Unilever).

(4) "The strength of the UK science base will inevitably be a fruitful source of innovative ideas." (British Airways).

(b) However, the UK may not be so adept at always accepting the risks involved in bringing these good ideas to the marketplace. Shareholders and fund managers want to minimise risks and this makes it difficult to invest in any long term speculative new products. In the consumer durables market the retailers also have finite shelf space.

(c) "Winning business is about the application of integrated capabilities to the business opportunity and the capabilities (technology, skills, knowledge, tools and facilities) provide the bridge from the science base. The UK science base by every international objective measure is very strong and it is not a priority to make it stronger; the priority must be to develop the capability bridges." (British Airways).

(d) Not only is the UK science base already a fruitful source of innovative ideas for UK industry, increasing globalisation means that the world is full of ideas for doing things better. The challenge for UK industry is to capitalise effectively on the global pool of ideas, not all of which warrant development.

2. *How successful have the Department of Trade and Industry (DTI) and other Government Departments been with their range of initiatives designed to stimulate innovation?*

(a) The DTI's initiatives came in for praise from those companies that have used them:

(1) The "Innovation Manufacturing Initiative" was seen as being generally successful.

(2) The "Eureka" initiative had proved successful for cross-border research collaboration.

(3) The "Technology Foresight" programme received mixed reviews, although it had successfully brought together the Government, Academia and industry.

(4) The SPUR grant system had produced a strong success story for a specific software development project.

(5) The DTI's Innovation Unit has been seen to have done a great deal for manufacturing industry.

(b) The DOE's "Partners in Technology" programme and LINK schemes are useful to the construction industry.

(c) The general criticisms of Government initiatives did not challenge the effectiveness of the schemes but rather their scope, applicability and promotion:

(1) There may be too many separate initiatives and they may be focused too much on SMEs. It was suggested that it is usually the larger companies that take the technology to the marketplace and in the global context the competition is dominated by the larger companies.

(2) The initiatives may be one-dimensional in that they do not have appropriate funding mechanisms in place to encourage the movement of an idea along the "innovation chain" to successful exploitation.

(3) DTI's initiatives for business links should be extended into the construction industry. Government Departments involved in construction projects should also become model clients.

(4) The existence of schemes still needs to be publicised.

3. *How effective in terms of product or process innovation and other exploitable outcomes are initiatives which encourage collaboration between industry and academia?*

(a) Only one company (Rolls Royce) saw the initiatives as generally effective, and even then wrote that "...there are too many of them with different rules and requirements...too many of them have not been industry-led so that industry is not fully engaged with much of the work carried out with Government funds."

(b) There was again criticism that the focus on SMEs was to the detriment of the larger, world-class companies which were turning increasingly to overseas R & D funding, and this would jeopardise the UK's science and technology base in the longer term.

(c) There was a view that conditions were improving, although the construction industry was likely to want to see some short-term benefits if its support was to be sustained.

(d) Among the many suggestions for improving the picture:

(1) Intellectual property arising from (Government-funded?) academic research should be given freely to and owned by UK industry.

(2) There should be a free flow of researchers between industry and academia.

(3) "The UK should establish centres of research excellence similar to the Fraunhofer Institute in Germany. This approach brings the benefits of critical mass, focus, continuity and development of world-class competence." (T & N Ltd).

(4) The media can be more helpful in changing the cultural attitude rather than assigning the concept of innovation to a political doctrine.

(5) Good links exist with academic departments for specific technical areas, but there is no mainstream industry-wide link at the local level.

4. *Does financing need to be improved for technology-based small firms during their crucial start-up and early development phases?*

(a) The unanimous response was that finances did need improvement with the important caveats that:

(1) The first phase that required additional support for technology-based SMEs was market and user research.

(2) Support was also needed for industry in the scale-up costs of technology demonstration prior to full product launch.

(3) The funding mechanism needs to be faster.

(4) Checks and balances on the standards of funded work need to be maintained.

5. *What other support systems could be introduced to ensure that the maximum advantage is taken of innovative ideas that originate with individuals or, for example, in academia?*

(a) Again, Government support for market and user research, particularly for smaller companies.

(b) A Government Project Fund might be established. A business case would be made, with partnership between industry and academia, for a particular idea. It may then attract funding for an agreed period. If milestones are satisfactorily achieved and the innovation is brought successfully to the marketplace a royalty would be paid for an agreed period to help defray the original grants.

(c) A system for managing the whole process of converting an innovative idea into a commercially exploitable product should be introduced. On a national scale the UK would be able to maximise its use of its excellent science and technology base. In turn this would require various bodies, Institutions, funding sources and industry to collaborate throughout the entire process. It is believed that this system may operate in Japan and Germany.

(d) Better publicity and promulgation of existing support schemes should take place such that the concept of innovation and its outcomes becomes known to school children, teachers, local industry and professional Institutions.

(e) Better links need to be established between academia and the real marketplace and Government support for schemes such as the Construction Productivity Network must be sustained.

(f) The exploiting companies need to be engaged earlier in the innovation chain. This may mean adjusting the operation of existing research council funding mechanisms.

(g) The concept of the great "National Competition" should be re-examined. In the UK's technological past such competitions stimulated considerable innovation and development towards a greater objective; for example, the first accurate chronometer. Currently in the USA there is a $1 million prize to the individual producing the first non-NASA reusable orbiting space craft.

6. *Is there institutional inertia towards the funding of technology-based small companies? If so, to what extent may this be due to financiers' unfamiliarity with science and technology concepts and what should be done to address this?*

(a) Some believe that investors dwell too much on short-term returns and are neither familiar with nor tolerant of the needs of innovating companies.

(b) Engineers need to improve their knowledge of the "finance culture".

(c) It might be useful to provide an incentive "cushion" which protects the short-term consequences of failure against the benefits of success in the longer-term.

7. *The Committee recommended tax credits for research and development in our previous enquiry. Would this still be an effective way of fostering innovation and how should they be introduced to ensure that they are roughly cost-neutral?*

(a) All respondents saw this proposal as important and effective, but there was no consensus about achieving cost-neutrality other than seeking partial reimbursement from the successful companies.

(b) Tax credit was seen as a form of sponsorship over which industry would have the major control, although it was assumed that the Government would, in due course, wish to define what was admissible R&D.

8. *How has the Technology Foresight Exercise influenced the availability of development funds for innovative ideas that were not given short-term high priority status?*

(a) The Technology Foresight Programme has been successful in bringing together Government, academia and industry to identify future technologies of importance to the UK. However, the focusing of funds into priority areas needs to be handled with great caution. "Our track record in the UK in the area of technology forecasting is not encouraging." (Unilever).

(b) "Technology Foresight has largely failed to influence R&D spend . . . the Foresight 25 year projection is too long . . . some Foresight Challenge funding . . . is available although its relevance and impact are uncertain . . . the Foresight report for construction is very general in nature and has not contained tangible recommendations . . ." (Taylor Woodrow).

(c) "Apart from Foresight Challenge and small adjustments to priorities by some Research Councils, the response to Technology Foresight in terms of reallocation of funds is still awaited. There is a real requirement to ensure that the Government £6 billion Science, Engineering and Technology budget is allocated and prioritised . . . in a way which will lead to adequate support being made available to all technologies identified as critical under the Foresight initiative, including those of lesser priority." (Rolls Royce).

9. *Has the tax relief introduced in 1992–93 for individuals' expenditure on vocational training had any impact on the status of continuing professional development, in particular for employees in small firms?*

(a) "Not a great deal, since the majority of employers/employees/unemployed have yet to realise that a career is the individual's responsibility, albeit the planning of a career should be a partnership of understanding between them." (Parsley & Waters, CPD Partnerships in Learning).

(b) "Fairly insignificantly for employees in large companies with well-established training schemes." (Rolls Royce).

Examination of witnesses

MR BRIAN KENT, Chairman, Board for the Engineering Profession, MR MICHAEL GOULETTE, Project Director, Advanced Engineering, Rolls Royce plc, and MR RICHARD HODKINSON, Taylor Woodrow, representing the Engineering Council, were called in and examined.

Chairman

248. Good morning.

(*Mr Kent*) Thank you. My Lord Chairman, my name is Brian Kent, and I am Chairman of the Board for the Engineering Profession within the Engineering Council. I am an industrialist and have worked for many years in engineering. I know quite a lot of the background in terms of universities, because I am the governor of a university; Parliament, because I have been Chairman of the Industry and Parliament Trust; and engineering, because I have been the Chairman of a number public companies; so I can dodge around this triangle which I think we will be doing today.

(*Mr Goulette*) My responsibility in Rolls Royce is for advanced engineering, which means I have responsibility for all of our research and technology activities within the aerospace group. My background is that I have been at Rolls Royce 32 years; I joined them as an engineering apprentice, studied as a metallurgist and have been in the materials area most of my career, but now I have broadened out into the broader range of mechanical and aerodynamic engineering covering all of the technology issues.

(*Mr Hodkinson*) I am a Chartered Civil and Structural Engineer, and I lead the construction technology facilities of Taylor Woodrow. Taylor Woodrow are a major construction company who work internationally, facilitating a wide variety of types of projects—a wide variety of different contractual forms, including design of projects, site work and commissioning. I am very much involved in the bringing forward of research into the front end of the business. I am very concerned with the whole innovation process to yield profit and benefits to our business.

(*Mr Kent*) I am sure you are aware that the subject we are discussing can be sliced so many ways: clearly, manufacturing and construction is one slice; large companies and small companies is another one; and, therefore, we will do our best to focus on particular parts of this complex matrix, but it is a very complicated subject. As we represent the Engineering Council of 39 institutions, I am convinced I will upset somebody, but we will do our best. We have present a past Chairman of the Engineering Council, Lord Tombs, and he knows what I am speaking about. We are very grateful for the opportunity to address you nevertheless, because it is a key subject, and the Engineering Council is central to this situation. In our written submission we did make a number of points, and I would just like to remind you of them. The United Kingdom is not short of innovation. There is plenty of innovation in British industry. We also believe that in general terms we have a very strong science and technology base in the universities and establishments. What we are really here to discuss is how we can harness this to get the best for the nation out of this valuable resource. You will hear us use a number of words today which we have debated. We will talk quite a lot about "innovation chains", and we will talk quite a lot about "supply chains". We make no apologies for this, because we think we should focus more of the Government's efforts to these two areas: innovation chains and supply chains. You will hear us talk about "mentors" to assist in funding decisions, and supporting small companies in particular. We are very keen on the incubation process, which has been mentioned in the Bank of England report. Finally, you will hear us make some comments inevitably on the role of government agencies, which we are grateful for but we are critical of some of the things they do, which I am sure will interest you. We are probably against trickle-down funding, where a lot of money goes in the top and everybody gets a little bit at the end. We would rather see some more focus. We are not too happy with the idea of asking people for 5 per cent of purchasing to be spread around. Again, we think that is the crude way of doing it, and there must be a better way. Those are some of our likes and dislikes.

249. Thank you, that is very helpful. As you say, focusing in this area is extremely difficult. It may be helpful before we start the questioning to say that since the Committee did address a similar area a few years ago, what we are endeavouring to do in this enquiry (which was, to a certain extent, stimulated by the Bank of England report and the request for debate in that report which you mentioned) is to focus in on those aspects of those issues which have either not made progress over the past few years, and that is obviously a disappointment, or areas where there has been change which we could then build on, or where possibly some changes have been negative. Having said that, perhaps I might hand you over to the gentle hands of your past President to start the questioning.

(*Mr Kent*) So the fast bowler comes on first!

Lord Tombs

250. Mr Kent, would you say there are important differences between innovation in large companies and innovation in small companies and, if so, how would you compare them?

(*Mr Kent*) I do think there is a difference, but I think Michael could perhaps start from the large company point of view.

(*Mr Goulette*) I think there certainly are some differences, but I think the issue we felt was important in the discussions we had previously was this issue of the supply chain, which we mentioned in the introduction. In order to have effective innovation, wherever it might occur within the manufacturing sector of industry, it is important

Lord Tombs *contd.*]

there is a strong connection between the end consumer at the top of the supply chain right down through all of the supply chain through to the bottom end, the manufacturer, for example, of the material. Innovation has to take place at every link in that chain. As far as large firms are concerned, they are inevitably reliant on small firms to provide them with the capabilities they need in order to integrate a product at the end of the day. It is our belief that, in encouraging innovation, one of the things the Government should be doing is trying to encourage the formation of effective supply chains, and invest in a way that will encourage the formation of those supply chains; and that means investment at every level in the supply chain; but it also means investment in large firms, in encouraging them to form links further down the supply chain. We think, if we can see there are mechanisms coming about which will improve the formation of those supply chains that is something which is very important. In thinking about the differences between large and small firms, I think we also have to think very carefully about the linkages between large and small firms, and how the small firms can connect more effectively into large firms who, in most cases, will be their customers.

(*Mr Kent*) In the case of large companies, sometimes the majority of the supply chain may well be inside the company itself. As we know, Lord Tombs, it is sometimes more difficult to get departments within the same company to cooperate than outside companies. In the case of small firms you may have to identify one, two or three small companies you can bring together in the supply chain. There are one or two excellent examples of this. There are one or two around Leeds and Sheffield where they have focused upon medical matters, and they have brought together small companies that are linked clearly; and the consultant surgeons who use the product are actually participating, sometimes as shareholders, in groups of industrial enterprise. It is quite small, but all have a common purpose. One of the big advantages, of course, is the rate at which they can turn the surgeon's request and idea into a product, and they can sometimes do it in two days. It is another matter, of course, then developing that into a business. I think there is a difference in technique, but I think the issues are just the same. In construction there are particular problems with the supply chain which I think Mr Hodkinson would like to comment on.

(*Mr Hodkinson*) Building on that comment, I think innovation is essentially a collaborative process, not only involving people in the supply chain but involving universities and specialist companies. In construction we suffer from a fragmented industry. We are driven by short-term project requirements, low capital cost-driven requirements, and bringing innovation into industry is extremely difficult for this reason. There is very little technology transfer between different projects. One can receive excellent innovation on a single project, but transferring that innovation through into different projects and through different companies is very difficult.

Viscount Caldecote

251. Rolls Royce have always had a very good practice of keeping in extremely close touch with their suppliers, to the extent that you certainly used to and no doubt still do, tell your suppliers several years in advance of the kind of service you require from them in terms of products, and this enables them to innovate to meet your requirements. Is that still the case? Do you think more could be done in the rest of industry to imitate you?

(*Mr Goulette*) It is certainly the case in Rolls Royce and will continue to be the case, but you need to go one step beyond that. It is not just a case of communicating between the customer and the supplier, it is also a case of partnership between the customer and the supplier. Unless you work in partnership with your suppliers towards a common goal which you both clearly understand then progress is very difficult. If all you are doing is just passing information down it is very difficult for the supplier to actually understand how they should make the best investment, and where they should put their often limited resources in order to provide the best possible result. Information flowing down the supply chain, which says, "These are the requirements; these are the needs", opportunities flowing back up the supply chain, and partnership at every level in the supply chain in order to achieve the overall ends of the supply chain as recognised, is really the way forward. What we have to find ways of doing is to encourage that linkage to operate more effectively.

252. Would the Engineering Council see a need for that practice to be extended more widely throughout industry?

(*Mr Kent*) I think so, yes. These two gentlemen are here because they are industrial affiliates of the Engineering Council, and one of our quests is to build bridges between research, industry and departments. This eternal triangle which I referred to, the building of bridges and keeping them open for small businesses as well, is important. I would bring in here the role of government as a purchaser. One of the things that government has not done in this country, particularly on construction projects, is think about supporting a project in order to develop technologies and try them out so that they could then be used elsewhere in the construction industry, and would also help our thrust for overseas projects. The drive, as one can imagine, for government money and spending and getting the lowest price is sometimes not balanced by getting technology development. The Americans have a lot more money than we have but they do this very much on the defence side, in stimulating particular projects in order to develop technologies. You can actually do it on the construction side as well. I think the role of government as a purchaser should be examined in terms of innovation, developing and transferring technology for UK plc at large.

Lord Tombs

253. I think the notion of the large company in which innovation is continuous and incremental involving suppliers is really commendable, and good companies do that, but it is largely homogeneous. I am thinking also of the small companies with limited resources, not clearly defined markets and bright

ideas. The innovation process there is different in many respects with the absence of support.

(*Mr Kent*) Yes. I will give you some statistics, although I am sure you have had a lot. One of the major banks has said 408,000 small companies are formed every year and 400,000 disappear. The hit rate for the survival of small companies is extremely small. However, I met the other day a director of the Prince's Trust and I asked him about the survival rate of the Prince's Trust companies, because they support something like 2,500 companies, and to my astonishment he said it is 60 per cent. Therefore, you say to yourself, "What is dramatically different between what they are doing and what is happening at large?" This is where I think we have come across this aspect of the mentor. They take a lot of trouble at the Prince's Trust to allocate maybe a retired engineer or a retired businessman to the project to help them through; because a lot of people do not understand the financial side; a lot of people do not understand the engineering issues they are facing. If we could harness the growing proportion of skilled people who are unemployed but who want to give something and link them then maybe we could raise the survival rate from 2 per cent to 10 per cent, and also help the innovation process. Lord Tombs has said, if a guy is on his own who does he talk to, who is his speaking partner, how does he know he is not reinventing the wheel? He needs a speaking partner, and that is crucial. If we could put the two together by some means I think the costs could be relatively low and we could get some dramatic changes.

Lord Cuckney

254. I was interested in the Sheffield/Leeds example. Do you know who took the initiative for that; who leads it?

(*Mr Kent*) I think it was a chance meeting of a top surgeon who wanted a particular instrument for keyhole surgery and a businessman who knew perhaps where he could get it. This opened up the realisation that there was a need for a supply chain that was reactive and that was effective. One of the problems with an idea is, initially, there may not be a large market for it, and it may be highly specialised; therefore it can either come from the market, i.e. the surgeon with the need, or it may come from the other end, of somebody who does think he is rather clever at creating something and he goes around and offers it to different people. I think the Sheffield one came out of the medical end, and then an entrepreneur spotted it and started pulling together supply chains, and he has done very well out of it, and then publicly you can flog them, as I well know as I did it two years ago.

255. I was just wondering, my Lord Chairman, whether it was an agency or some corporate body who suggested this and put it together?

(*Mr Kent*) No.

256. It was an individual initiative?

(*Mr Kent*) One of the gentlemen concerned also talked to me the other day about the effectiveness of the Local Business Link. He was very praiseworthy of it. He had a factory producing large fabricated structures and he was thinking of where he could find a market, and I said to him, "Have you tried Germany?", because Germany is trying to shed jobs overseas to get costs down and is shopping around for things like that and we are a very good place to come; and he said, "It's funny you should say that, Business Link introduced me to a German company and I have quoted and got the first order". That was excellent to hear, but in a way it was predictable because Germany is now looking to getting its costs down and is coming to this country looking for subcontractors, and there is an opening market there.

(*Mr Goulette*) I think linkage is very important. Finding a way to connect the market requirement to the technical opportunity or the business opportunity which is being developed in a small company, or even in a large company, is extremely important. I think to some extent we have seen within the DTI initiatives that in the last few years they have concentrated on technology transfer. I think technology transfer is not the biggest issue. The biggest issue is: how do we connect the need with the opportunity? It is getting those two linked together, not moving technology about, which is the key issue. If there is one message I would like to put across it is: how do we improve these linkages between the end customer and every level in the supply chain and the opportunities that are flowing out through the supply chain?

Lord Flowers

257. Years ago one used to have research associations and one thought very highly of them and government departments backed them and so on. You are using a totally different language now, as I understand it—research associations are now national in coverage—and you are talking about the supply chain, and things are closely geared to, I presume, individual large industries or small groups of large industries and things of that sort. Is the research association idea completely out of the window now?

(*Mr Kent*) I believe that is a different subject. To me, the only way to tackle the small business is on a regional basis. The only way to get at all these companies is on a regional basis, and the different regions of the country have been more successful than others. The north-east in particular has been very strong on a regional basis. For large companies it is an international basis, and that is a different ball game altogether. Therefore, I think the research angle is very specialised, and tends to be a large company gain and not a small company gain. Our friend from Rolls Royce can perhaps comment about that issue. I would not like to offend the research associations because I am sure they do a fine job.

(*Mr Goulette*) To come back to the issue we talked about right at the start, which is the innovation chain or the technology chain, there are a series of phases you have to go through, starting from a bright idea which goes on in the university or at the research level and taking that right the way through to being exploited in industry. The research associations were aimed at a particular phase of that innovation chain. I think the problems with research associations were that they were assuming people could come together

Lord Flowers *contd.*]

to work on a particular aspect of research almost in the absence of an effective pull from the market. What we have to do is to get an effective pull from the market and then drive this whole process of going from basic research through to the fundamental application. That means we have to have effective basic research, and we have a very strong science base in the United Kingdom—I really do not feel we have a problem there. It could actually be argued we are over-investing in the science base at the expense of the more applied research. The second phase is applied research, and that is really where the science base collaborates with industry in order to produce something which starts now to be aimed at a real market application. The next phase, and the one which I think we are least effective at in the United Kingdom, is the phase of taking that applied science and then demonstrating it, validating it, doing pilot plant, doing the investment that is necessary to take the risk out before we go and apply that new area of technology to a real product. That is an expensive process; it is one which is difficult for industry to find the funding for, but it is vital if we are to be able to react quickly to the marketplace and have low risk technology solutions available when we want to develop a new product. I think that is an area we are severely lacking in, in the United Kingdom; it is the whole issue of: how do we get that investment in before we start product development to take the risk out of the new technologies?

Lord Dainton

258. The impression I have got from your representation of chains is that they are demand-led, but we have not touched on innovation-push at all. In your written evidence you put a lot of stress on the problem of finding the right idea and how it is to be identified, and somebody has said the science base is very good. Can you tell us what is wrong with that, if anything, and how it could be improved: the identification of new ideas, particularly as affects the universities?

(*Mr Kent*) I would like to start off with the university situation at large. Incidentally, I worked out my own home-spun formula from business over many years. I think you make money when market pull equals technology push. The problem is managing that. If you have an idea, you have the technology push but you have no market for it, so you are funding that technology and it is costing a lot of money, and some companies can go bust because the market either never develops or they do not crack it. Other people have a large demand for their products—the market pull is very big—and they cannot satisfy it, and competitors come in and steal it away. If you can get the beautiful situation where the two are equal then I think you make a lot of money. Therefore, the art of management is to manage that process, and I think you have mentioned it. In terms of the universities, we believe collectively in centres of excellence. Therefore, I think the present drive to focus on centres of research, particularly in universities, is a good one. Sadly, some people regard that as an elitist comment. I think research needs a focus, and needs centres of excellence. The problem is, it can be very profitable for the university. A lot of universities are making money out of research in quite a significant way. If I could quote two: Strathclyde University are now in the main league, almost the same as MIT, in terms of the amount of income they are generating from research. Surrey University, where I was the other day, have now put up 12 satellites which they have designed for governments, most of them with the Ariane rocket and the next one is going up with the Russian rocket. This is a profitable business and it makes a big income into the university. One of the slight worries is, are now the universities in need of funds so much that they have to develop these businesses to generate the income upon which they begin to depend? Therefore, is the research becoming too business-led within the university, and is becoming sacred because it generates so much money for the university for funding reasons rather than pure academic reasons? I know some industrialists are now slightly concerned that, in fact, research in the universities is going that route. Having said that, Rolls in particular, but a lot of other large companies, have got marvellous relationships with our universities and are building a bridge with those universities. There are strings attached, of course, because any university needs guidance and freedom, and any commercial enterprise needs protection on the ideas that are produced; so who owns the intellectual property is an interesting debate.

(*Mr Goulette*) It might be worth briefly describing the way we in Rolls Royce interact with the university sector. We have built up long-term relationships over a long period of time and we have now 11, what we call, university technology centres in particular areas of technology that are relevant to our business. We fund these technology centres on a rolling grant basis of the order of about £200,000 a year into each of these centres. The concept is that we will work with them on applied research which is directly relevant to Rolls Royce within the context of that rolling grant, but encourage the university to build its science base around that area as well in terms of fundamental science, so that they are effectively building a long-term capability which we can then tap into at a later time. The aim would be that our funding of, say, £200,000 per year might be doubled by funding that is coming in from EPSRC and the other research councils into that area of technology within the universities. That gives us a very powerful capability, because from our point of view we are getting very good science, we are getting very good knowledge and we are getting very good technology; and from the universities' point of view they are getting help in terms of directing their activities; they are working in an area of science and technology which is relevant to industry. That is exciting and they can see the application for it; it is also stimulating them to do some very good and fundamental science. We believe that is an effective way forward. Certainly within the aerospace industry we are seeing other companies picking up that model and using it.

(*Mr Kent*) One of the things that does not exist, and this is a shame for the small businessman, is a book that tells him which university to go to if he needs a particular activity investigating or help

Lord Dainton *contd.*]

with—that does not exist. He, therefore, usually goes to his regional university, but that may not be the best place to go. There is scope here for a year book or something to be issued, because it is all published information within the university itself, but they do not like to compete. It would be rather nice if there was a reference catalogue, so if you were dealing with something to do with a satellite where would you go? I have mentioned one place, and there are probably two or three universities where there are centres of excellence on particular things. Everybody knows for manufacturing systems you would probably go to Warwick, but you cannot find that in a book. If you are a small businessman needing help, it would be nice to point you in a particular direction, but that does not exist.

(*Mr Hodkinson*) I think in construction relationships with universities are far more *ad hoc*. We do not have these long-term relationships that large manufacturing companies have. One thing we do have to do is manage those relationships. We cannot establish links as a company with 50 universities, it just is not possible to do it. We would far rather develop relationships with a fewer number of universities but develop those relationships in some depth. We are not very keen on placing all of the research simply in the university; we would far rather have a collaborative effort, bringing together academics and industrial people on a joint project. In that way we can retain some kind of market focus. That does not mean to say we would necessarily lead the work, because very often blue skies research we are involved in is better led by the academics. Certainly we do not like a detached approach, a detached relationship.

Lord Dixon-Smith

259. Thinking about what I call the intellectual property market and the way it is used by business, surely there must be a clear distinction, or is there likely to be a clear distinction, between the large enterprise and the small enterprise? I imagine if Rolls Royce cannot find the intellectual property development going on in this country that it wants and it sees it going on in America or Japan it has no hesitation, and for you the intellectual property market is global?

(*Mr Goulette*) Absolutely.

260. Whereas for a small enterprise there is a very clear distinction because they do not have the contacts that would make that possible. Are we not seeing a situation where our universities, flowing on from that, have to recognise that they, equally, are operating in what is effectively a global market and they must be aware of what is going on across the whole span of the enterprise?

(*Mr Goulette*) I think that is true to some extent but, having said that, the effective development of technology takes a long period of time, and transfer of technology is something which is not carried out easily; it requires the transfer of people; it requires long-term communication; and it requires a proper understanding of the fundamentals behind the technology. I think the notion that you can simply market technology on a global basis is, to some extent, flawed. Technology cannot easily be packaged up and transferred around the world. Our experience is that we work with universities abroad, but we tend to work with them on a much more limited basis than we do in the United Kingdom. We find that the long-term relationships we have with universities in the United Kingdom are far more valuable to us than the ability to be able to go out into the global marketplace, because they facilitate the transfer of technology, and they facilitate the transfer of both requirements and opportunities to and from industry. It is that long-term relationship that is essential to get effective innovation both within the universities and within industry.

(*Mr Kent*) I contacted the Federation of Small Businesses before I came here, and they made the point (the conclusion we had drawn as engineers) that the patent problem for small companies is quite severe. The cost of registering patents internationally is enormous for a small company. It is an illusion to think that all small companies are just United Kingdom-focused. Some quite small businesses do a lot of business internationally. If they have something that is patentable then I think we should try and encourage them and also support them for international registration where necessary. That is something that perhaps government could help with in terms of the high cost of doing that. It is quite important. As a nation we are way behind the Japanese in terms of registering patents. The Japanese do them metaphorically "ten a minute". We do not do as many as perhaps we should. The Americans go hot and cold on this, because you publish so much information in America to patent they are worried about that, and therefore some ideas are not patented because of that fact. Probably the Japanese lead the world in registering patents, the Americans are probably in the middle, and we are probably at the bottom of those particular three. There is a culture issue here. I think it would help small businesses if we could find a way of supporting their patents on an international basis, particularly in Europe. On cross-country deals and discussions at government level we would like that point to be made—what about the small company cost?—perhaps within the European Union.

Lord Dainton

261. Elsewhere you have also referred in your evidence to a "global pool of ideas". Can you tell us how significant that is, either for small businesses or large businesses in this country?

(*Mr Kent*) In what context did we comment about a global pool of ideas?

262. Tapping the global pool of ideas. How do you tap them?

(*Mr Kent*) I think we are back to international supply chains.

263. Is this coming back to the small firm: he needs somebody to help him with this specific problem?

(*Mr Kent*) That does help. We talk about technology, but it comes in many forms, and I prefer to talk about know-how. It is quite surprising how ignorant small companies are on what a large company-trained person takes for granted—it is

quite astonishing. Just to illustrate the point, many years ago I joined the CBI Council and on my very first day I met a gentleman who had a very nice manufacturing business in South Wales, and he knew I knew something about machine tools, like Viscount Caldecote. He complained that the particular machine tool he wanted he was having to buy from Germany, and since he placed the order it had gone up in price by 20 per cent and he was having to pay more for it. I said, "Didn't you buy the D-marks on the day you placed the order?", and he said, "How do you mean?" I said, "Go to your local bank manager". I saw him six months later and he said, "You've saved me a lot of money. I did not know you should buy the currency on the day you place the order". That is so simple, but it is a piece of technology that I, as a large company employee, would know, but is not available to a small man. I think we are back to mentoring again. We have to get that input to guide the small man with his idea. I was asked to go and look at an invention many years ago where a man, in his own garage, had effectively invented the linear motor and he did not know Professor Laithwaite of Manchester University had also registered it. He was terribly distraught because it was his life's work. He had actually built virtually a small locomotive in his garage that was effectively the linear motor. He had worked it out himself but he did not realise Professor Laithwaite had already published the paper and registered it. Again we have to transfer this knowledge.

Lord Flowers

264. You say that small technology-based firms need to improve their market research during early development stages. Is this an implied weakness of the innovators or the investors? Do innovators not know enough about market awareness? From what you have just been saying that might be the case, for some people at any rate. Or is it the investor's insufficient technical knowledge? At an earlier meeting we were told that scientists and engineers have to learn a lot more about financial rules, and I am sure that is true; but when one goes into the financial world nobody knows anything about technology, yet they are trying to back technological development. One wonders if there are not faults on both sides. What do you think?

(*Mr Kent*) The Chairman of the Pru made a very courageous speech the other night in the City. He of course has some background in marketing. He made the point, with most of the chief executives present of large companies, that Britain has not been good at marketing in general; it has not been good at marketing. We have been good at selling; we have been good at technology; but we have not been very good at marketing and applying that. The general picture of banging the marketing drum I approve of. In particular, the question you ask, I think it varies whether the invention is creating a new market; and he probably does know quite a lot but may not have done the research. We are talking money here. Market research properly done is quite expensive. Therefore, I think it is quite difficult to blame either/or. It can be both. I have not found bankers to have lack of knowledge on technology or market, because they can buy it before they put their money on the table. I have been associated with venture capitalists, and I am very impressed with the basis by which they decide to invest. They have 100 ideas come to them a year and they back one of them, and therefore they do their homework; but, you see, they have money available to do this. We are back to resources allocated to the small man to do his market research.

(*Mr Goulette*) I think there is an issue here in large companies as well. They have to think very carefully about where they are going to invest their money in technological developments. It is very easy to invest in things which will not result in enhancement in the product. This is not just an issue for small companies; I think within large companies there is a need to improve the way we make decisions about where we are going to invest in technology.

(*Mr Hodkinson*) I would like to make a point that the market will always win. Unless we can actually generate a new market or offer savings, then the thing will not fly. The other concern really is the speed at which the relationship between the market and the inventor has to work, and how that can be facilitated; and also the way in which our contractual arrangements in construction very often are barriers to exploiting a piece of technology. For example, we are largely capital cost-driven, and yet many inventions may reduce the whole life cost of a project. Offering that to a client is quite difficult in our contractual arrangements. That is why the earlier point Brian made about using government as a model client, taking a project and taking an invention and demonstrating real savings to be made, is a very important part of this process—things that could be done in a government situation that perhaps could not be done in a one-off commercial situation.

Viscount Caldecote

265. You mention in your note about the importance of engineers getting a better understanding of financial factors. What is the Engineering Council doing to promote that? I would add myself, what is the Engineering Council doing to improve, what I call, the management of investment in technology, project management if you like—two things which are extremely important where we very often fall down?

(*Mr Kent*) Now it is much tougher to become a chartered engineer than it was in our day. We are introducing at the moment new standards for the different types of engineers, both chartered engineers and incorporated engineers. It is probably impossible today to become a practising engineer unless you understand a balance sheet, unless you understand wider aspects of business. The universities have got that message. We in the Engineering Council, who set the standards, are quite determined now that an engineer must know something about management—because to some extent we have paid the price for that. Marketing is slightly more for choice. I would say that not every engineer has necessarily been exposed to that discipline. I think in terms of finance, if I may be so bold, even a research

Viscount Caldecote *contd.*]

engineer must understand a balance sheet, because the money is big and the risks are high. I do believe what the Engineering Council is doing now, in pushing the standards up and being very specific with the universities (and some are crying wolf), is quite correct. We are also focusing very hard on the incorporated engineer which, in simple terms, is the practical engineer that industry requires; because they are complaining that the graduates they are getting have something wrong with them. Even the large companies are saying they are not quite getting the right type of engineer. We are probing this. It does appear that the syllabus is now so crowded for an engineer, and the teacher ratio is now so low, that it is quite difficult now to have time to discuss engineering as a philosophy. All the time we are pushing information in and people come out having taken engineering as just another subject; whereas in our day we took engineering because we had the feel for it. There are particular problems we are addressing. I think I can say we have that message and our engineers are becoming world class.

Lord Dixon-Smith

266. It would be interesting to hear your views on the Government's measures to reorganise its innovation support initiatives. Whilst I think in your introductory remarks you said you did not like the idea of a 5 per cent purchasing budget being allocated in a particular direction -it does seem to me that would enable the Government to fulfil one of your other requirements which is, to a certain extent, product-approbation, and also the point of it being possible to use that to encourage particular innovation in construction programmes and so on and so forth. What you have said so far is slightly in conflict in one context with things you have said in a different context.

(*Mr Kent*) I think as regards the amount of money, the 5 per cent is perhaps a good number. What we are challenging is the way it is applied. 5 per cent across the board as an edict to all purchasing agencies is a rather blunt method of dealing with something which is very sophisticated. Our message is: "Okay, we'd like 10 per cent, but 5 per cent we will settle for as a sum of money, but the way it is directed and the way it is used should be focused". That is the other reason why this terrible world of trickle-down of funding is awful. Giving everybody in this room £10,000 because they have all got a idea, to be fair to everybody, is awful. I would rather give £100,000 to the Lord Chairman—

Chairman

267. Yes, please!

(*Mr Kent*)—because perhaps her ideas are going to deliver it quicker. Having tested them against all we have been talking about this morning is much better. The Government have got the message, I think, that there are too many people running different schemes, and we have found out the small businessmen have never heard of quite a lot of them. The Smart Scheme does seem to have been very good. The MacRobert Award from the Royal Academy, the Manufacturing Effectiveness Award from the Institutions of Mechanical and Electrical Engineers, the awards within civil engineering, are all very good at supporting these ideas, but we have still a long way to go to get national recognition of this and to flush out those people who would like to apply. They do not realise that government money is available, and therefore we approve the rationalisation. I dream of having a television programme on prime time that is the Oscars for innovation, and watching all the engineers walk up and get their prizes. That is what I dream of. That probably suggests the money has to be there—three cheers for the Lottery; and basically we have to get people to realise that we are battling. Everybody has been talking about this for 20 years. I attend conferences about what is wrong with manufacturing, and one chairman the other day said, "We said this 20 years ago and what has happened?" There is something wrong with what we are doing because we are not making the progress we want. Therefore, our answer is focus; large lumps that appear visibly promote them nationally; and shout from the tops of buildings that we are very good.

Lord Dixon-Smith

268. I am all for shouting from the rooftops that we are very good. How do you manage this process of focus in the context of the Government having a pretty poor record, one has to say, of picking what should and should not be done in a particular field? It is notoriously bad at picking winners.

(*Mr Goulette*) I think the Government has started a process of picking winners, which is really what Foresight was all about. I think we have to exploit the work which has been done over the last two or three years around the whole exercise of Technology Foresight, which clearly was not perfect but I think it engaged industry and academia in a very effective way. It has developed a lot of linkages which were not there before; it has started to help to engage the supply chain we talked about earlier; and it has identified some real priorities which both industry and academia feel are important for the future of the United Kingdom. Why do we not build on that? We are saying that it is not being built on as effectively as we want it to be built on. The government initiatives should really be focusing on what Foresight is telling us, and taking that process further. Foresight is all about understanding what the needs are and backing winners. We should not be afraid to back winners. If I could also comment on the point about the 5 per cent budget for small companies. I think there are two issues which concern us about that: one was the implicit assumption that innovation can only occur in small industries, which I think is fundamentally flawed; I think innovation occurs in all sizes of companies and needs to be encouraged in all sizes of companies; and, the second thing is, we need to avoid the situation we see in the United States where they have a similar law, where we end up with small companies who exist wholly on the back of government funding with no route to market except to exploit more government funding. In the aerospace industry in the United States that is a

Lord Dixon-Smith *contd.*]

common phenomenon, and one which is a very poor use of government money.

269. There is another distinction there between small and large companies in this innovation field, and that is that large companies are always operating with considerably large revenue streams, whereas small and innovative companies often are having to start with no revenue stream at all. The reliance on government money surely has an inevitability about it to start with?

(*Mr Goulette*) I would not disagree with that view.

(*Mr Hodkinson*) I would just like to say, of course this is an issue which faces business all the time, which research to continue and which to drop. We start many projects and at some point we have to take a realistic view as to whether it is worth pursuing and the way in which we try and do that is to have some kind of objective and some way of measuring our progress towards that objective and one has to be realistic.

Chairman

270. I am afraid the clock is treating us unkindly.

(*Mr Kent*) My advisers behind have mentioned two things that we have not covered. We do think that a national competition highlighting innovation sponsored by the government would lift the profile. We really do. And there are a number of agencies, including the Engineering Council, which could help the government in doing that. Other countries do it and I think you could have different sections. It could have a prize for helping older people in innovation or it could have a prize for helping particular sectors of society and direct interest into those areas and I think that would be very very helpful. I think we would press over and over again the words we have used on supply chains, on innovation chains, and mentors. I think it is directing the money that is available more carefully rather than asking for more money and we should have larger lumps but fewer rather than spreading it evenly across everybody. There is quite a lot of seed funding available but seed funding runs out after one year, two years or three years and I have found a lot of disasters where people have been thinking they had a viable situation not realising that their support was disappearing in six months' time because they had had it for three years and a man or woman should start thinking about the funding that he or she has got to have after the three year seeding is over on day one and not on the last day of the third year. That is our message. Thank you very much.

Chairman] Mr Kent, Mr Goulette, Mr Hodkinson, thank you very much for coming to this Committee. I only wish we had longer.

Memorandum by BTG plc

BTG plc is a world leader in the commercialisation of science and technology. Many industry-changing products have reached the world via BTG including pharmaceuticals, diagnostics, agrochemicals, materials, medical electronics and engineering products.

BTG, formerly a public sector Statutory Corporation (formerly NRDC, then British Technology Group) was privatised in 1992, was floated on the London Stock Exchange in 1995 and has a current market capitalisation of about £400 million.

Historically, technologies came to BTG almost solely from the UK public sector and we estimate that currently we have filed between 30 per cent and 40 per cent of the patents directly attributable to the UK Universities. Although 60-70 per cent of our licensees have been UK-based companies, for the past twenty years about 80 per cent of BTG revenues have arisen outside the UK.

Privatisation has freed BTG to operate internationally. We believe there is a large, and largely untapped market, to increase BTG's business outside the UK and with companies as well as university and public sector sources. Today about 40 per cent of BTG's technologies come from corporations and about 30 per cent from outside the UK. Some of the new sources with whom we are working are noted in Annex 1.

Our view is that investment in the science base is primarily to increase the knowledge base and to train people (see Annex 2). Invention is not the primary objective of universities. Occasionally, as a "byproduct", specific transferable technologies may emerge. The majority of the "technology transfer", or innovation benefits derive: (a) from skilled people moving into industry; and (b) through companies undertaking research at, or in collaboration with, the universities. Much of this output has the characteristics of an international public good. Nonetheless, value should be captured from specific technologies when they arise and where that is possible.

It is important to recognise that in technology, just as in other markets, the UK operates in a global market. It would therefore be damaging (as well as illegal) to try and legislate for "UK invention to UK industry"—the technology equivalent of mercantilism. UK industry looks world-wide for the technologies to keep it competitive and unfettered flows of technology are an important part of that process. Equally, UK Universities need to look world-wide for partners.

We believe that the UK continues to have a strong and creative science base. We agree with those who

believe that intellectual activity such as R&D has a good future in the UK as an economic activity in its own right.

Although improvements can always be made, and some are noted later, there are a variety of processes and mechanisms which have and continue to work successfully in the UK. The view often expressed to us is that the effectiveness of existing DTI schemes needs to be strengthened rather than adding to the options. BTG itself has little direct experience of these schemes and therefore cannot make an informed direct comment.

The starting point for universities to contribute to industrial innovation needs to be strong local commercial and research support to enable the universities to be competent at academia-industry relations, research contracts, technology audits, research grants support and providing commercial awareness to academic researchers. Some universities do this very well, others are catching up. Over the past 10 years there has been a major improvement.

DTI initiatives to undertake technology audits and strengthen university competencies in this area have improved awareness, strengthened the University Directors of Industrial Liaison (UDILs) but to our knowledge, unsurprisingly, have uncovered little under-exploited technology.

Specific and valuable technologies emerge from universities in a random and relatively rare way. When one does, skills of a high order are required if maximum value is to be created, be it through licensing to major companies or through a start-up company. Similarly, the financial risks from a worldwide patenting programme ($250,000) or the money to be invested in a start up are large for a university, particularly as it may be unable to support a portfolio of sufficient size to lay off the risks.

The UK, compared with most countries, is quite well endowed with this tier of companies to provide such expertise, provide the risk capital and take the commercial risk. We are still in transition to a pervading entrepreneurial culture and all that goes with it. For example, in the US much of "angel" capital comes from friends and family who have created some personal wealth. Managers are more prepared to run a start-up if they have some personal wealth behind them. Finally the culture of risk taking remains far more deeply ingrained in the US than the UK. For example, the penalty of having run a start-up company which then fails is significant in the UK. In the US it is more of a battlefield medal which earns the right to do it again or to try again on a larger scale. The legislative constraints to risk taking in the UK remain significant, particularly those that relate to bankruptcy.

One area where more possibly needs to be done is the so-called Development Gap where we find that companies are often less willing to take a risk on "long-shot" technologies. They often look for more proven technology with lower risk. This is true of most companies, not just in the UK. In order to persuade companies to take up technology we find that often quite small amounts of money are needed to take technology the first step towards demonstrating commercial viability. From time to time an expenditure of £5,000 to £50,000 is needed to show proof of concept, build a demonstrator or perhaps provide additional data to be convincing to a potential industrial partner.

BTG currently invest about £1 million per annum in this way. But we do not see all potential needs, nor do the universities always want to accept the commercial quid pro quo for such investment. We believe that there is some need for additional funds to be used in this way but which are subject to proper commercial forces. It is very easy to waste a lot of money on "good technical ideas" and we would not necessarily endorse government funding of such investment. However, it is an area where there is commercial potential on which a number of companies and funds are focussing, as is BTG.

BTG has supported many technologies through a spectrum from start-up to licensing. One recent example is that of Peptide Therapeutics. We supported the work of Professor Stanworth for many years. We tried to license the resulting allergy vaccine to industry. However, companies at that time were not interested in that area of science and declined to take it up. [It is worth noting that this area of chemistry was the only one to receive the highest ranking in the Foresight Delphi survey—an interesting comment on how scientific fashions change over quite short times.] We then encouraged the start-up of the company Peptide Therapeutics to take the concept to a more advanced stage—which it has done very successfully. It is still likely that the ultimate development and marketing will be by a major company, but PTL successfully bridged the gap. BTG has a number of other, similar stories.

We have some concerns about the number of people in the UK with the right abilities, background and motivation to create and run start-ups. We see this management gap as a principal constraint to increasing the number of start-ups, not a lack of finance which we believe to be available for good proposals.

Some technologies lend themselves to being licensed directly to major companies. In the case of MRI, for example, which we have licensed to 99 per cent of the industry, it is very unlikely that any one company could satisfy world demand. It is virtually impossible that a start-up company could have developed the technology as the majors have, or satisfied demand for what is now a $1.5 billion per annum industry. It is worth noting that all our licensees are outside the UK: GEC Picker manufactures in the USA; Siemens and Philips in Europe; GE in the USA and Hitachi, Toshiba and Shimadzu in Japan. A UK start-up based on the Aberdeen University MRI research group was not a commercial success. Our experience in MRI reinforces the need

for a global view, where one key objective must be to get a technology into the market place quickly and effectively for the benefit of the end user/customer—the patient in the case of MRI.

The UK university sector deploys many tools to get technologies it has invented into commercial use. These provide a useful adjunct to their main role of training people and providing a stimulus to companies with whom they work.

I will be happy to expand on these points in my evidence to the committee and to answer any questions you may have.

Ian Harvey
Chief Executive

13 January 1997

Annex 1

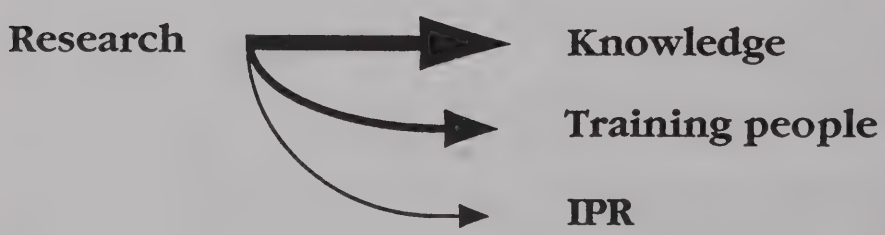
Selection of Overseas and Corporate Sources

- American Cyanamid Company
- Århus University (*Denmark*)
- University of Arkansas
- Biogen, Inc.
- Campbell Institute for Research and Technology
- CSIC (*Spanish 'MRC*)
- CSIR *(South Africa)*
- Dupont Merck Pharmaceutical Company
- Eli Lilly and Company
- Flemish Biotechnology Inst.
- GEC
- Genetic Engineering Inc.
- Grumman Corporation
- ITT Corporation
- Johnson & Johnson
- University of Lund (*Sweden*)
- Princeton University
- Rolls Royce

Annex 2

Technology Transfer

IPR is a BY-PRODUCT of public research



Examination of witness

MR IAN HARVEY, Chief Executive, BTG plc, was called in and examined.

Chairman

271. Mr Harvey, welcome to the Committee.

(*Mr Harvey*) Maybe I could first comment on the Bank report itself. In terms of the Bank report we think it is an excellent report, its analysis is very good, and we agree with most of its broad findings. I would make three points, to reinforce two points. The first is having spent around half of my working life in the United States, that the United Kingdom is in the middle of a major culture change and has been so for the past ten to 15 years. Certainly this is something I have seen continuing as I have been working with BTG. The change is one of culture, of entrepreneurialism, of risk-taking, of management skills, but there is still quite a gulf between the United Kingdom and the United States. If we are going to be better at bridging this gap and better at creating the links, part of it in my view has to be a continued change in culture within the United Kingdom. There are still some fundamental differences between the United Kingdom and the United States in terms of the delight in making money and being prepared to take risks. I think those are the two key areas. Also the quality of management in small to medium-sized firms we do see as a key constraint. It is improving in this country but one of the recommendations, for example, was to improve the links between business schools and universities' scientists and engineers. That is a recommendation that we would certainly endorse. I would like to amplify and maybe add to some of the comments made on page 32 of the report about technology transfer and intellectual property because I do not believe in that one area it is wholly complete. I would certainly agree with the summary: "There may be potential for further commercialisation of research and for closer links between universities and firms." However, I would challenge at least half of the statement: "The commercialisation of academic research is far less developed in the United Kingdom than in the United States". In the spin-out of companies the United Kingdom has been much less successful in the past, although it is changing. But in the area of technology transfer (patenting and licensing) historically the United Kingdom has been much more successful than the United States. I have brought some data with me that reinforces that and indicates the nature of the change. We were asked in the early 1990s to participate in a seminar being run by the DTI "to learn from the US experience in technology transfer." The people we invited over included the Heads of Technology Transfer from MIT and Stamford. They stood up and said, "We have been talking on the plane coming here and actually we feel that the United Kingdom is the model we should be looking at rather than the US model". The chart I have just given you indicates that in the US in 1989 and 1990 the total royalties from the US university and government research sectors combined were around $120 million. In the same period the United Kingdom earnings from royalties were just over $100 million, despite the fact that the United States spent in that period roughly five times what the United Kingdom did on R&D within those sectors. So in a rather simplistic assessment, the United Kingdom was five times more successful at generating royalties through patenting and licensing than was the United States. That deficit in the United States was in large part due to two things. The first was that the United States government did not permit exclusive licensing and it did not permit the licensing of non-United States firms. The result was, for example, that much of the excellent work done at the National Institutes of Health, which is one of the world's foremost centres of medical research, did not get into companies and therefore into patients. This is because, of course, it is necessary to have an exclusive licence for a pharmaceutical product and many of the best pharmaceutical companies lie outside the United States, particularly in Europe and, of course, the United Kingdom as well. The result was that virtually nothing came out of the NIH to become a pharmaceutical product. In the late 1980s United States government policy changed, modelled very much on that of the United Kingdom. They decided that if they were going to be effective at technology transfer they were going to have to allow exclusive licensing and the licensing of non-United States firms. That has transformed the situation in the United States. I have some more data which I can put in front of you which is the university data which shows that following the period from 1989 to 1990 (when the earnings were $120 million) in the next two years the earnings went up to approximately $298 million and that trend has continued. As the United States universities have been freed up to license worldwide and to license exclusively (which is the United Kingdom model) then they have become much more successful than hitherto and they are approaching the United Kingdom level of success in generating royalties from patenting and licensing. That is a very long-winded way of saying that the United Kingdom is very good at patenting and licensing and we should not ignore that. The other side of that coin that the report really does not mention, nor do a number of other government-funded reports, is the quite dominant position that BTG has had in the protection of university patents. Although we have become increasingly involved in technology transfer out of large corporations (which is a new part of our business which has developed over the past three or four years) the heart of our business still lies in patenting technologies arising largely within the United Kingdom university sector which is very creative. We estimate that we file somewhere between 30 and 40 per cent of all the patents generated by the United Kingdom university sector. There were two reports recently. One was by *Tartan Technologies* for the DTI and the other was done for the EPSRC by the University of East Anglia both of which identified the patents produced by universities. The patents owned by BTG on behalf of the universities were excluded from that data. If we add to the numbers which they brought out the number of patents which we own on behalf of the universities, it roughly doubles the number of patents which they had identified. We do feel that both historically and currently we play an important part in capturing value from inventions within the United

Chairman *contd.*]

Kingdom university sector. What has changed is that the universities are becoming much more creative themselves. We have the ability to be much more selective because we no longer have the obligation to patent and licence everything which comes to us and that has been beneficial for both sides. We work with the universities on those major technologies which have the potential to create a great deal of value and where our expertise in the worldwide patenting and licensing of the technology can generate significant value and help the product get into the market place to the consumer where it will create value. Of course, as we may talk about later, the support system in the United Kingdom, venture capital, seed capital, the willingness and desire of people to spin out firms, is also changing. So the UK is changing, particularly on the spinning out of firms which has got a lot better, but we have further to go yet. I would just like to make one further addition to the report. They do refer to the SBIC in the United States and they refer to the financial support for small companies. I think there is another element of the Small Business Administration work which is not mentioned here. It may not directly fit with the report but I think it fits within the purview of this Committee. That is the requirement for much government procurement to be supplied by small and medium-sized firms or from firms which are owned by minorities. I think around 25 per cent of all procurement, particularly in the defence sector, has to go to small firms. So, for example, if there is an order for 100 F15 fighters to Lockheed or whoever makes the F15, ultimately those companies have to be able to track down and say that 25 per cent of that work has been supplied by small and medium-sized business or by minorities. This has had a very powerful pull through effect which is not present in this country at all. One of the comments in this country has been that the biological sciences have been more successful at getting out into the market place than the physical sciences. I think one element behind that, if you look at the defence industry in the United States, it is largely the physical sciences, aerospace and electronics. The requirement to purchase goods and services from small and medium-sized firms provides a very large market for those firms when they are first formed and when they are growing. In this country, having been a director of a small start-up electronics firm myself, I know how difficult it is to create those first orders. I think it would be interesting for you to look, if you have not already done so, at the experience of the United States in the SBA in directing a certain proportion of government procurement to the small and medium sector.

Lord Currie of Marylebone

272. About two-thirds of your licences are United Kingdom based?

A. Yes.

273. A slightly larger proportion of your revenue comes from overseas. That reflects the success you have had in selling those technologies overseas. Is there a more negative assessment that British-based companies are less effective at exploiting the new technologies than companies overseas?

A. I think it would be wrong to draw that conclusion. I think there are a number of factors why that proportion is so. It comes from a lot of historical data when we did tend to patent everything that moved even if it was not particularly commercial and we would try and find a home for it. The result was we probably signed licences for things which were not going to have a particularly large market. If you sign a licence for something which is not valuable you are probably going to do it in the United Kingdom rather than travelling to Japan. So I think in the time period during which these licences were created there was a much wider spread of the value of the licences to be signed. I do not think the United Kingdom is any better or any worse than most countries at "not invented here" or the ability to exploit. This country has only five or six per cent of world industry. To be generating 20 per cent of revenues from United Kingdom industry when we are talking about worldwide products, probably is not bad.

Viscount Caldecote

274. Could you tell us how does the risk/reward ratio for new start-ups differ between the United Kingdom and, for instance, the United States? If there is a difference in the sense that our investors look for a lower risk/reward ratio? What can be done to improve the wider follow up of innovation?

A. I think this is one of the most difficult areas and I have spent a lot of time thinking about it. I confess I do not have any specific conclusions or recommendations to make to you, because I think there is a very big difference between the United Kingdom and the United States including the availability of seed capital. Having spent a lot of time with United States venture capitalists and the rich individuals who invest in the early stages, what in the UK is called "angel" money, a lot of that is quite irrational investing, gambling. You have rich investors who have a few million to invest and they will take a gamble by putting $200,000 or $300,000 into a small firm, not because they expect to have a return but because they think, "It could be an Apple or a Microsoft", and it is really the same as investing in the Lottery; on balance you will lose. There is a very good example in the United States in the late 1980s in the hard disk industry where there were 50 start-up companies and if you were an investor in companies number 15 to 50, the probability of seeing a return approached zero because the market would in fact only support three or four, if that. Nonetheless, you would find people putting a lot of money into those early stage start-ups. But if you were a rational investor—and most of the money in the United Kingdom in seed capital and venture capital comes from pension funds and therefore you must be a rational investor—you must have a reasonable expectation of making money. That is where there is a gap in the United Kingdom. You do not have a sufficient number of rich individuals who look forward to gambling some of their money into these small firms. I think it is that that we lack.

275. For that reason some of the good ones are missed?

Viscount Caldecote *contd.*]

A. Some of the good ones will be missed but a lot of the bad ones will not be invested in also.

276. That is a good thing?

A. If you look at the economics of lotteries, individuals putting money of their own free choice into economic activity, at worst is neutral and at best beneficial. If you use tax money to do the same thing I think it becomes more questionable.

Lord Flowers

277. You say: "Invention is not the primary objective of universities." I think I know what you mean by "invention" so I think I can agree with you. Assuming that you agree that teaching and fundamental research are amongst the main functions of universities—

A. Absolutely.

278.—The question that I would like to ask is what other responsibilities do you think universities should try to undertake? It has been argued in front of us, by Amersham amongst others—and they seem to have an astonishing affinity in attitude with you although you have not discussed the matter with each other—they argue that it is the role of universities to provide research options for companies to take up and develop. Now that is going rather beyond saying that the universities' responsibility is basic research. I suppose the Technology Foresight programme in a way bears upon this but in any case if you impose upon universities the idea they are producing options for companies, who is going to manage that process? What do you see it involving?

A. I think probably your assumptions about my meaning are right, which is that I do not see it as being the principal objective of publicly funded research in universities to come up with patentable inventions. They are random, they occur relatively rarely, but may be of significant value. When they happen you should try and capture value from them. As I tried to indicate in the chart behind here, of course education is the primary purpose along with fundamental "blue skies" research. They will train people and I think what Amersham were saying, which I would wholly agree with, is that by undertaking fundamental research the universities are opening up new avenues and are creating options for the companies with whom they link up. And I do think it is very important for universities to forge links with industry, it is a two-way street, so that industry is aware of what is happening at the cutting edge, not necessarily to pluck a particular idea out of the universities with whom they happen to be associated but so that they can identify a company to acquire within the United States or a research group to work with in Japan because they happen to have a particular product or work in a particular area which is going to be important for that particular firm. I see that universities, by undertaking very high quality fundamental research, by linking with industry and finding that industries also have interesting fundamental problems to be solved, get into a virtuous circle. But not so that universities are doing applied research to develop products for industry. I think most companies would say that is best left to them. The fundamental ideas and the knowledge of where the science is going, the technology is going, a large part of that can come through the university linkages which we see as being very important.

279. Thank you for that and I agree with what you said, but the question really is the extent to which you are prepared or somebody is prepared to distort, if I may use the word, universities' basic research activity in order that it shall be geared towards providing options for companies to develop. I think there is a serious problem there.

A. I think that the MRC has shown that the two things can live in peaceful co-existence, in fact in a mutually sustaining co-existence, because most of the MRC research centres do very good fundamental research but they also do applied research, the need for which has been identified by the companies for whom they work, I think the researchers find that the two sets of input aid and abet each other and they are not in conflict at all. Just one further point, if I look at a university like Cambridge and the Department of Chemistry there, which gets several million pounds a year in unfettered funding from Ciba-Geigy and a similar amount for research in areas of interest to the company, all the researchers working within that funding are inter-relating with each other, their ideas are feeding off each other, but if you talk with researchers at Cambridge, who value their academic freedom as much as most, they would say it is a very exciting environment in which to operate.

Lord Dainton

280. You heard the discussion that took place or part of it with the previous group. One of the concerns you must have detected is the interface between the universities, and BTG is a successor of NRDC in its own right and has really been what I thought engineers who gave evidence to us were looking for, in a sense it has been the mediator between the universities and industry. Is that right? When you answer that can you tell us what your views are about some of the suggestions which were put to us by the previous group. For example, would an inventory of research activities add to the permeability of this supposed innovation barrier? Would it be useful to the universities to know how they can get in touch with venture capitalists, matters of that kind, or do you regard the present situation as an improvement on the past and working sufficiently well?

A. Could I start with your first point which is the role of BTG. We manage intellectual property for other people. Historically that was United Kingdom university technology but now 40 per cent of our technology comes from companies and 30 per cent comes from outside the United Kingdom. That intellectual property is only a very small part of the university output, as I said. We are not good at it, we are not placed and we should not be managing the interface for the universities between themselves and industry. That is something they themselves have to manage. Sometimes it is talked about whether universities should group together for this purpose. I do not think that is a good idea because universities will grow and flourish if they are working in their own self interest. We have been part of a group in the

Lord Dainton *contd.*]

United States, the Delaware Valley Consortium, which we helped to create, which was a grouping of 13 universities and about 20 venture capital institutions with the aim of creating better links between United States industry and that group of 13 universities and research establishments. It was funded in large part by the Ben Franklin Centre in Philadelphia and about $1 million a year went into it. That has not been successful because the universities keep the best things for themselves, they keep the best contacts with industry for themselves, so that when you have collaboration then actually you are collaborating on the least important things. In my view collaborating like that actually moves away from the self-interest of the universities creating the kind of links which they need and should have and which start from the individual researcher, the department and the university as a whole. If you take an example like Strathclyde where I think Hugh Thompson and the Vice-Chancellor and all who work there have been very successful in creating different kinds of mechanisms by which they can interact with industry. With Strathclyde, for example, if there is a technology of significance BTG may well be one of the groups they talk with to create and capture greatest value from it. Our role is one small part of what universities should be doing. I think the United Kingdom universities are certainly doing much better than they were doing ten years ago, but, as was said in the White Paper three or four years ago. This is only part of the problem. I think the major problem is the receptivity of the United Kingdom companies to what the universities are trying to create. I think the universities are doing quite a good job. The best of the United Kingdom companies respond extremely well, from the Rolls Royces to the Glaxos. But the small to medium-sized firms, as is so often said, are often badly-managed. It is not just technology; it is good management; it is the marketing, the sales skills and the customer understanding they often lack.

281. Reference was made earlier to the Prince of Wales Trust being very much more effective here because of the use of some people with business experience going in. Is that your experience?

A. We do not have a great deal of experience with the Prince of Wales Trust so I cannot comment.

Chairman

282. On the point that Lord Dainton raised about the suggestion of a directory or index of researchers of some kind, if it is your view that a lack of information is creating a market failure with respect to small or medium-sized businesses, is there a role for such an information source and, if so, who can provide it?

A. That information source already exists and has done for six or seven years in the Cartermill International Ltd databases, and the European R&D database published by Bowker Sauer which is freely available to everyone in hard copy and CD-Rom.

283. As far as the Engineering Council is concerned obviously there is some failure at some point. You are wisely not replying!

A. I think if you hook onto the Web you can find what is going on in United Kingdom research or in research in Japan with great ease. I have come from the World Economic Forum in Davos where Bill Gates was complaining how far behind the United Kingdom and the rest of Europe was in the use of Web. That is certainly true. We are not using it enough. To have a meeting with a company who said as they came in and put up on the screen, "This is the information I downloaded from the Web last night of what the five following research groups are doing in Japan and research they have published in the last three weeks" shows that what you can do is very very powerful. We need to be plugging into that because the information is certainly available. It is available in hard copy with the database I have just mentioned and certainly via the Web and the Internet it is freely available.

284. But there is a distinction between the form of publication of such an information source and whether there is a need for it. There may be massive amounts of information available, but that does not mean to say an intermediary could not be effective in channelling information to small and medium-sized businesses. Do you see such a role?

A. When Sir Robin Nicholson was chairing ACOST he made one comment which I thought was very appropriate, that we need more receivers listening, not more transmitters beaming out!

Lord Flowers

285. Is it not the case that unless the author and title, so to speak, is available on the Web nobody in future will know that it exists because they will not look through hard copies in libraries, they will look through the Web. It does not matter whether the information is used on the Web or not, just as long as it exists?

A. That is a very important area which could start a whole new line of discussion particularly as far as IPR is concerned. Such information could constitute prior art and in fact could be very damaging to patent positions for major corporations in the future because if something has been on the Web and it has been taken off as hard copy it can emerge in ten years' time to destroy the patenting position of any manufacturing firm. One of the government support schemes I did think was effective was providing advice to small and medium-sized firms because there you have people who do understand what the company needs to be doing and actually did act as an intermediary between all that is going on outside, identifying the companies and filtering all the information which is certainly available and putting it into digestible useable forms for a company.

Lord Cuckney

286. How do you differentiate between funding for proof of concept and seed capital? Do you see proof of concept funding preceding capital?

A. It is a continuum. We see ideas that we think have the germ of being commercially valuable but may not yet be patentable, perhaps because the university data is not very good because much of the

Lord Cuckney *contd.*]

university data is not done to industrially acceptable standards so you have to re-do some of the research and get the notebooks properly authenticated and so on. That is the first stage. Then you have to put together something which is convincing to industry which can be persuasive either to industry or to first stages of venture capital which would be to create a person or a small group of people who can develop the concept further. It is difficult to generalise because engineering is quite different from electronics which is quite different from biological sciences but we do see a need for funding at this very early stage. We put about a million pounds a year ourselves into trying to fill that gap and we are actively at the moment looking for ways of bringing in additional sources of funding either from venture capital or from new sources to increase the resources available within the United Kingdom for that purpose.

287. But the £1 million funding you provided, what form does that take? Is it in the form of a loan or capital?

A. We will provide our funding in return for ownership of the intellectual property rights.

288. It has an equity element?

A. Absolutely because it is very high risk and, as the report says, at this stage it has to be equity because the interest rate on a loan—

289. I was very interested when earlier you were saying that the pension funds are a source of seed capital. Is that your experience?

A. The pension funds through the various intermediaries so that venture capital companies, like Apax Partners for example, have made a small proportion of their investment capital available to the seed capital area.

Viscount Caldecote

290. What would be the average size of investment making up your million?

A. It ranges. I do not know what the average is but the lowest will probably be £1,000 and the largest will probably be £100,000 with somewhere between £5,000 and £25,000 being a fairly common sum.

Lord Dixon-Smith

291. To what extent does the reluctance of universities and/or individuals to give up stakes in their intellectual property rights, particularly in relation to new ideas, affect their ability to raise funds for exploitation? Is there a problem with the distribution of rights between universities, industry and principal investors? If there is, how should we manage it to make the most favourable impact on increasing innovation and the exploitation of innovation?

A. I think it is probably less of a problem now in the universities than it is for the individual entrepreneur outside the universities because the universities have been quite good at educating their researchers that actually invention is only five per cent of the process not 95 per cent of the process. If the idea is going to be taken forward then all the other things need to be brought in, the development, the capital, and so on. Most good university technology transfer officers are very helpful at educating their researchers. If this idea is going to move forward then they are going to have to give up equity for it. The problem comes more with those who have been independent and really do not understand. Again, that is a significant difference between the United States and the United Kingdom. United Kingdom researchers have not liked giving up control and they have not wanted to bring in people from outside whereas in the United States if you can get Hambrecht & Quist, the venture capital company, on board backing your idea, that is wonderful because they are well-known, they will help you manage it, they are going to make money for you, whereas in the United Kingdom they are going to take money away from you because they are going to take away some of the ownership. Just talking about the cultural differences, my children were brought up initially in the United States and when they were going to primary school aged three or four they were taught about trade, about doing business, they were taught about creating win-win situations in games as well as in business. If that kind of thing had been taught to under-fives in this country—when my daughter first went to school in Salcombe her annual report said she was much too ambitious. That is the depth of the cultural differences we still have. Just going back to the venture capital, it was certainly interesting with the privatisation of BTG that there were a lot of venture capital companies interested in participating but none wanted to take the lead. When Cinven, the Coal Board Pension Fund Managers, decided to take the lead the rest came in because they relied on the judgement and due diligence that had been undertaken by Cinven. We are trying to do something similar in the United Kingdom, to some extent in the United States also, because venture capital does not always understand the implications of intellectual property. We can do the scientific due diligence to see whether the research stands up in practice and we can provide some of the input into the future commercial value of an invention which will add to the work that a venture capital company itself does. As I made comment in my formal submission, I said we are increasingly working with venture capital, where we are one of the partners, to provide comfort to several parties that the IPR is in place, it is properly looked after and we are finding that is helpful to venture capital in the start-up area. We are looking at creating different kinds of partnerships which have not existed here before.

292. Are there changes particularly in the taxation regime which you think might help to induce the cultural change that is required?

A. Given the evidence from other countries about the imperfections with which tax breaks work, particularly the Australian evidence where really it was a very inefficient way of inducing a change in behaviour, I would be very reluctant to say a change in tax breaks is going to be economically effective.

293. But would they do anything that would be what I would call psychologically effective?

Lord Dixon-Smith *contd.*]

A. Having looked at how BES schemes have worked and so on, I think money flows to where it will create the greatest value with the lowest risk. You might have a marginal increase in funds going in but I am not sure it will have a significant impact.

Lord Kirkwood

294. Mr Harvey, you made a statement in your submission which says: "We have some concerns about the number of people in the United Kingdom with the right abilities, background and motivation to create and run start-ups. We see this management gap as a principal constraint to increasing the number of start-ups ..." If there is this management gap my question is, is this a problem for or of the education sector and, if so, who should get this management training and at what stage? We have been told by a previous witness that the university courses are stuffed up to the gills for engineers in particular and there is always a danger that when you push in something more into the curriculum some of the fundamental parts of the training of an engineer will be lost. So how do you envisage this sort of input being added, for instance, to an engineer's training or to whoever requires it? Maybe it is not that, maybe it is the teaming up of experienced managers and investors seeking suitable advice when considering innovations to fund which is needed.

A. Your first question opens up some very broad issues as well as the narrow issue of management training, and with Lord Tombs sitting there I am reluctant to go too far, but as an engineer myself I felt my training at Cambridge was far too narrow. Every moment was time-tabled and I had no time to do any other courses whatsoever. I think that is very damaging and if one says engineers should be running United Kingdom industry, having engineers who do not have management skills running United Kingdom industry is not a good idea. That is changing but I do in very general terms endorse a broader education not a narrow one. I would endorse, for example, going into an International Baccalaureate 18-year-old qualification. My son is now considering the International Baccalaureate, including business studies as part of it. It means by the time you graduate with your first degree from university you will have a less detailed knowledge of some engineering areas than you might have otherwise but my view is if you want to get that specialised knowledge you go and do a Masters or PhD, hopefully a taught one, so that (as in the United States) you understand the broad nature of your subject not one particular part. If you want to become a highly skilled researcher then you can do that also. The breadth of education is very important and in the United States, when I went there to do my graduate work I discovered that what I had done at A-level in physics and maths was approaching the level that many people were achieving graduating with their bachelors within the United States. But they then went on to do their Masters and PhDs. I certainly endorse management education but you cannot force feed it and you cannot just spray it out. We need to be looking at ways, universities in particular, of helping the companies with whom they work to become more aware of management issues. But you have to create a demand for it. I was in the United States a couple of weeks ago with one of my colleagues and he had a seven o'clock business seminar for two hours. He was advising people about how to improve management skills in bio-science start-ups. People paid $100 a head for that two-hour session and there were 250 people for a meeting starting at 7 and finishing at 9 before they started their real work for the day. I do not think you would find that kind of demand here. So we do have to work very hard to increase the level of management skills both by helping on the supply side with what the universities are doing, the linkages they are creating and by a variety of methods, some of which the government has used to increase demand from the companies themselves. In terms of the start-ups, in the United States you have people who make some money, maybe they have done well with bonuses or on the stock market, people between 30 and 40. The desire to run your own business in the United States is a very powerful one. If you have a little bit of financial backing also that does no harm at all. In the United Kingdom we still suffer from a lack of that kind of person. People who have been in industry, who know what running a business is about, who know what marketing is about, all the things which you need to have, to have those people going up and being available in the pool for managing start-ups is a resource which we are beginning to have but do not yet have to the extent that the United States has. It is certainly changing but I do not think there is anything you can do overnight to change that.

295. But you are also asking people to take on risks that perhaps they would not do in this country in their mid-30s or 40s. They are coming away from a stable environment, they have young families and all the rest of it and you are asking them to take a risk. That presumably is part of the United States culture; they will take that sort of risk?

A. Absolutely. I also refer in my written evidence to bankruptcy and I do not think we should underestimate the impact of that. I have been on the board as a non-executive of a small company that was facing some problems. I was a director of BTG at the same time and had I been a director of that company when it went belly-up that would have been a major black mark on my CV. Therefore, you run it in a pretty risk averse way. Whereas in the United States you run the company hard and when it goes belly-up you move on and your suppliers and financiers recognise that it is part of the cost of doing business and they should have checked you out better. The culture is quite different because the culture in this country does tend to be risk averse. You can see it in the laws on bankruptcy and pension legislation which I think is going to make pension funds more risk averse than they would have been otherwise because of the personal liability of trustees. You cannot take the risk out of life but I think in this country we sometimes try to.

Lord Tombs

296. You did mention just now your scepticism about university consortia as a means of linking industry. I quite agree with that for the reasons you

Lord Tombs *contd.*]

gave. Of course, the flip side of that is for industry the community of universities is a very diverse and bewildering one, for small industries even more so. I wonder if there are any lessons to be learnt from universities we have dealt with that are successful at this game of selling themselves, making contacts, that could be generalised? Are there any threads or is it all very individual?

A. As a broad generalisation I think it would be difficult for an average small company to work with an Oxford or a Cambridge but they would find it quite easy to work with a Salford or a Strathclyde. I think it is probably horses for courses. Particularly the former polytechnics are actually very good at creating the industrial linkages whereas I think the older universities are at the more ethereal but still very important end and their linkages will tend to be with the larger firms. So I separate them into two very crude categories in that way.

297. Do you think there is a correlation between those universities that have delegated departments for industrial research and their success? You mentioned Hugh Thompson. He is a very good example. Not all universities do that.

A. I think he sets a very good example. At Cambridge University the researchers can still do exactly as they wish but, on the other hand, the salaries are controlled and part of the *quid pro quo* is that they can do consulting, they can sell their ideas and they can start up firms and the whole thing balances out whereas in Strathclyde that is all controlled by the university which takes a slice of what is earned.

298. A modest slice.

A. A modest slice but then the salaries are not controlled in quite the same way. You have different ways of attracting people so I think it is quite hard to generalise other than the technology transfer officers do a good job. Certainly we would much rather work with a technology transfer officer that understands what the issues are and understands what the value is (or is not) of IPR and the way it relates to contracts with industry rather than work with people who do not understand it at all.

Lord Flowers

299. Mr Harvey, you made some very interesting cultural comparisons between this country and the United States about attitudes to innovation and start-ups and so on and so forth. Can you make similar remarks or contrasting ones between us and the rest of the European Community?

A. I think the United Kingdom does extremely well, certainly compared with Germany, France, Spain or Italy.

300. Why?

A. It depends country-by-country. If you look at Germany they have very rigid relationships set up between companies and, for example, the *Fräunhofer Gesellschaft* institutes. This is fine for contract research but when research is free flowing, as good research usually is, it means those ideas tend to go nowhere because they are constrained by the company with whom they have been working and if the company has no use for that particular direction of research then the idea will probably die. Therefore, the structural rigidity in Germany hinders the free flow and development of ideas. In Spain there is very little structure at all and we have been working there for about two years now and we have found some very exciting pieces of technology there in the most unexpected places and they are very happy to work with us. In France it is very much internally driven, although a shareholder in BTG is Anvar, a French government financing institution, which has the intention of encouraging us to work in France. In fact, the relationship set up with CNRS is such that it is French technology for French companies and, again, if you create that kind of rigidity, you reduce economic activity rather than promoting it. By contrast you have Denmark which has a very active system and Sweden is somewhere between the two.

Chairman

301. Mr Harvey, we could go on picking your brains for hours but we have gone beyond the time limit of this Committee. May I just conclude by thanking you and asking you if there is anything you would like to speak to that we have not questioned you on?

A. I think the depth and breadth of your questioning has sucked everything out of me! Thank you very much, my Lords.

Supplementary memorandum by BTG plc

ROYALTIES—USA/UK COMPARISON 1989 AND 1990

		Royalties	*Research Spend**
USA			
Universities		$113m	
Government Research Labs		$ 9m	
		$122m	$50b
UK			
BTG		$ 96m	
Other Universities	—Strathclyde	$ 6m	
	—Others	?	
		$102m+	$10b

*By Government for civil objectives

SOURCES: US General Accounting Office, Strathclyde University, Cabinet Office, BTG.

WEDNESDAY 26 FEBRUARY 1997

Present:

Cuckney, L.
Dainton, L.
Dixon-Smith, L.
Flowers, L.
Hogg, B. (Chairman)
Kirkwood, L.
Winston, L.

Memorandum by Mr Hugh Thomson, Director of Research and Consultancy Services, Strathclyde University

INTRODUCTION

The University of Strathclyde is primarily a technological university with faculties of science, engineering, business, education, and arts and social sciences. It has 12,600 full-time students, 954 academic staff, expends £18.6 million on research grants and contracts, and its teaching is of proven excellence according to the national review. In the Research Assessment Exercise the University's average rating improved to 4.57 (seven point scale) and this was achieved from a broad portfolio of research sponsorship in which industrial participation was at a high level. The University has worked hard to commercialise its research base; 22 companies have been spun out by academic staff with another six under consideration, and in recent years the University has been earning between £3 million and £3.5 million per annum from royalties earned from licensees.

The Research and Consultancy Services Office (RCS) at the University works with academic staff to negotiate and administer their research and consultancy grants and contracts, obtain EU funding for research and training, identify, patent and licence intellectual property, help staff to spin out companies and to form research institutes and centres within the University.

Hugh Thomson is the Director of Research and Consultancy Services and has been in post since 1984. He is an engineer who came to the University with a wide knowledge of manufacturing industry and experience of starting and running a small company.

EVIDENCE

(1) *Intellectual Property Rights*

The University encourages academic staff to identify the results of their research which may have commercial value. The Research and Consultancy Services Office has two people dedicated to protecting and licensing intellectual property rights (IPR). The University provides a patenting budget (£100,000 pa) and shares royalty income with the staff concerned.

A patenting strategy has been evolved which fully involves academic staff in the patenting and licensing process. Inventions which are thought to have some expectation of success are protected by a UK patent application provided the academic agrees to work with the RCS Office for the next 12 months to market and, hopefully, sell a licence. After this period the UK application is either aborted, or transferred to the academic, or is licensed, or is not licensed but is thought appropriate for the filing of patents. The latter is expensive.

The University has built up a portfolio of about 100 items of IPR which are either licensed, covered by an agreement, or have the prospect of being licensed.

The suggestion that ownership of IPR should be given to the academic staff is unattractive to the University, and, we think, to most of its academic inventors who do not have the experience, the negotiating skills, or the capital to undertake willingly the patenting and licensing of their own inventions. The University provides a professional service to the staff, shoulders the costs, and shares the returns.

(2) *Spin-Out Companies*

The University has a policy, approved by its Court, to support those academic staff who wish to exploit their research results through forming a company. In 1984 the University formed its Business Ventures Group (a working party of its Court) to provide advice, guidance, and investment, and to manage the University's interests in such companies.

The RCS Office implements the services and helps academic staff to translate concepts into formed and funded companies. It works closely with Local Enterprise Companies and helps to put in place the first round of seed-funding and to establish appropriate management teams etc.

(3) *Technology Development*

While the University has adequate access to the normal sources of funding for fundamental and strategic research, it has difficulty in obtaining funding with which to develop the results of such research for a year or two within the University in order to have technology which either is easier for industry to assess and is nearer-to-market, or is a less risky basis on which to form a new company. On average we judge that our research results are several years from being marketable; the University needs to be able to reduce the gap and meet industry part way.

Early discussions are ongoing with city institutions to explore whether they would consider investing in technology and its development and taking equity in IPR. Such a business would have different characteristics to investing in start-up companies and bears closer examination.

(4) *Seed Capital*

In the West of Scotland it is reasonably straightforward to obtain £100,000 or possibly £200,000 of seed *funding* from a variety of sources against a viable business plan but it is much more difficult to raise small amounts of capital in the range up to £500,000 if one's company has no track record.

(5) *Science Park: Incubator*

The University shares a Science Park with Glasgow University and the Glasgow Development Agency. It is 20 minutes distant from the University of Strathclyde but is an attractive location for the more mature spin-out companies. Most of the tenants do not have university connections, and strategies are being considered to attract inward-locating, high-technology elements of larger companies which have R&D links with the universities which can employ their graduates.

The University of Strathclyde has an Incubator Unit (run as company) on the Campus to provide support for embryonic companies for two or three years. 25 per cent of the companies (about 32 in total) originate from the University. The plan is to increase this to 50 per cent by concentrating effort on those academic staff who wish to see their technology exploited through a start-up company but do not want to run a company themselves. The need is to locate outwith the University, chief executives to work alongside an academic director. Such academics are highly motivated to provide all the technological support and are far more commonly encountered than the true academic entrepreneur who wishes to lead his/her own company. The University runs Technology Fora to expose such opportunities and has been approaching Scottish Business Angels (inter alia) to find business partners.

(6) For the last 13 years the RCS Office has been involving academic staff, through teamwork, in the more commercial aspects of their research. Where relevant they have been intimately involved in patenting, licensing, negotiating, marketing, selling and making deals. Many of Strathclyde's research staff are well able to conduct themselves in a business-like way when dealing with industry, and industry responds well to this ability.

H. G. Thomson
University of Strathclyde

20 February 1997

Memorandum by Dr David Thomas, Chief Executive, IMPEL (Imperial College's technology transfer company)

TECHNOLOGY TRANSFER FROM UK UNIVERSITIES TO INDUSTRY: A WEAK LINK IN THE CHAIN

Over £2·5 billion of government funding is provided annually for university research by the Research Councils, the Higher Education Funding Councils and other Government departments. Rather surprisingly no requirement is placed on universities to search systematically for commercial prospects arising from all this research. The matter is left entirely to chance. Each institution is free to decide whether to seek such commercial opportunities and pursue them to exploitation.

A few UK universities, at their own expense, are systematically carrying out technology auditing of their research. Some years ago DTI gave welcome pump-priming grants, reducing over a period of three years, to a number of universities for this purpose. Without such funding, the universities found themselves unable to continue the task unaided. Even the largest still find it impossible to resource their technology transfer

operations adequately, given present financial pressures. The largest team of technology transfer executives associated with a UK university numbers less than five. These executives have to market the intellectual property output of about 1,000 academics plus 1,500 research assistants and research students—a tall order indeed.

Technology transfer is a business characterised by long term return on investment. It can take from five to 10 years, depending partly on whether clinical trials are involved, from the time when a commercial prospect first appears to when royalties on sales start to flow. This in turn means that a technology transfer unit is unlikely to be able to cover its operating costs in its early years.

To fill this funding gap, one way ahead would be for all research grants to include a condition that a technology audit should be carried out to discover any items of commercial promise. Each grant would include an earmarked sum of, say, 1 per cent of its value to cover the cost of the audit. Perhaps it would be fairer for the research sponsor and the university to share this 1 per cent between them.

I have been promoting this idea. As a result EPSRC is conducting a pilot experiment in four universities, to end in March 1997, on best practice in technology exploitation. Hopefully the conclusion will be that EPSRC should henceforth earmark, say, 0·5 per cent of the funding on each of its grants, and require the university to match this sum pound-for-pound. These funds would enable an audit of the research to be carried out by a technology transfer executive in collaboration with the principal investigator. The findings would be submitted to EPSRC, complementing the report already required on the science.

If the Research Councils and other Government bodies adopted this approach, there would be a significant increase in the resources available for technology transfer units. The earmarked funds would be used to employ the additional skilled executives needed to conduct proper technology audits, to give advice on patenting, and then follow projects through to exploitation.

Within five years or so each technology transfer unit should be operating profitably on the commission (at say 30 per cent) on income earned for its university from licensing and spin-off companies. Experience in USA universities confirms this. Those UK universities with large portfolios of research should by that time be producing enough commercial prospects to support above-threshold technology transfer companies. The 1 per cent earmarking scheme could then be discontinued. Smaller universities may need to band together, or collaborate on technology transfer with a large university in their locality.

It is surely in the national interest that this aspect of the "development gap" should be addressed. The above proposal would be both cost-effective, if necessary with no new money, and unbureaucratic.

David Thomas—Short CV

Dr David Thomas was until October 1997 Pro Rector (Research Contracts) at Imperial College of Science, Technology and Medicine, with responsibility for managing the business aspects of the College's portfolio of research grants and contracts which last year brought in an income of £76 million. Simultaneously he was Chief Executive of IMPEL, the College's technology transfer company (a joint venture with 3i plc) and Chairman of IC Consultants Ltd (a company wholly owned by the College). He held the first and third of these posts for 10 years until he retired in October 1997.

He was asked to continue as Chief Executive of IMPEL on a part-time basis, and subsequently was also invited to become part-time Acting Chief Executive of Isis Innovation Limited, Oxford University's technology transfer company, in both cases agreeing to accept for an interim period until permanent appointments were being made. He remains a Director of five other companies associated with Imperial College.

During the last five years he has been Vice Chairman and then Chairman of UDIL, the UK University Directors of Industrial Liaison (recently re-christened AURIL, the Association of University Research and Industry Links). He has also served on various working parties of the Committee of Vice-Chancellors and Principals.

A graduate of Manchester University and Cambridge University (Pembroke College), he worked in the UK electronics industry before spending time on the staffs of MIT, Imperial College and CERN, Geneva. Subsequently he joined Rutherford Appleton Laboratory, then part of the Science and Engineering Research Council, finally becoming the Laboratory's Associate Director for Engineering. In 1983 he transferred to SERC's headquarters where he held the post of Director of Information Technology and was simultaneously on part-time secondment to the Department of Trade and Industry, holding the position there of a Director of the Alvey Programme, an initiative in advanced information technology, co-ordinated nationally. He moved back to Imperial College in 1986.

20 February 1997

Examination of witnesses

MR HUGH THOMSON, Director of Research and Consultancy Services, Strathclyde University, DR DAVID THOMAS, Chief Executive, Imperial Exploitation Limited (IMPEL) and Acting Chief Executive, ISIS Innovation Limited, DR DOUGLAS ROBERTSON, Secretary, Association of University Research and Industry Liaison Officers, Director of Research and Business Services, Nottingham University, and MR JAY MITRA, Head of Economic Development, University of North London, were called in and examined.

Chairman

302. May I start by thanking you very much for responding at such short notice to our invitation to come this morning. We are obviously under some time pressure, given both the uncertainty and certainty (if I can put it this way) that this Parliament will be coming to an end in the foreseeable future. Therefore, as we wish to get out at least some preliminary conclusions before the dissolution of Parliament, it was very helpful of you to come at such short notice. As you obviously represent a very diverse range of knowledge and expertise—which we wish to tap into ruthlessly in a relatively short period of time—and you will all have different perspectives on a number of questions, I thought it might be helpful if we could start by each of you, perhaps, having looked at the questions that we sent out, giving us some initial reflections.

(*Mr Mitra*) Thank you, Lord Chairman. I come from a new university and, therefore, the views I express are, hopefully, representative of some of the universities that we have been working with, including ours. These are not the views of my Vice-Chancellor, or indeed of my institution, specifically, but I think, looking at the issues that have been raised through the questions, we are, in a sense, less concerned with issues about IPR, for obvious reasons, because of the levels of research income that new universities attract, but also for other reasons, apart from the economies of scale. The other reason is that essentially they are issues concerned with what research does, where is the technology that is transferred in research and primarily based on a considerable critical mass of expertise in terms of working with small and medium-sized companies, which represent 90 per cent of the business community. Our concern is to see whether their applications have, in a sense, any value added in terms of small and medium-sized companies. We find that the gap between what is in fact done, in terms of the cutting edge of research, and what is translatable, as far as small and medium-sized companies are concerned, is immense, huge and under-funded. Also, significantly, the work that institutions do, including universities, is considerably short in terms of supply and considerably short in terms of understanding small companies. The traditional approach is that the "twain shall never meet". Kipling was wrong once and he is wrong here too, in the sense that there is less of an understanding in terms of what is it that companies want and what is it that universities can provide. Essentially, I am talking about small company interests. It is a kind of solution to problems, it is a kind of immediacy of purpose—not merely of coincidence but an immediacy of purpose. That can only be offered through multi-disciplinary approaches, through the provision at the leading edge, if you like, in terms of technology and its transfer, which meets the solution to the problem immediately but, also, goes beyond that in terms of meeting a range of needs which is often handled by the owner, manager and his or her cohorts. Perhaps I will limit my initial thoughts at that stage.

303. That is very restrained of you! Thank you very much.

(*Mr Thomson*) I am from the University of Strathclyde, Glasgow. At Strathclyde we are very concerned that intellectual property, commercialisation and innovation should not be seen as activities which are separate from the research function of academics; it is all part and parcel of their research business. So our stance is to work with academic staff to help them to tackle these extra areas of activity which are inextricably linked to their fundamental research programmes. So we involve them in the whole business of identifying research results with commercial futures, with the patenting process, with the licensing process and helping them to help us negotiate deals with industry and commerce. I think that is the first thing I would say. In a sense I reacted to one of the questions, where it is asked "Do we do enough to protect intellectual property?". In a sense, I would say that would be the easiest part of the task; it is reasonably mechanistic. The more difficult bits are to identify intellectual property, in the first place, and for that you need to have academic staff who are happy to sit down with you and talk about their research results, and they have to identify those results that they think have a commercial future. Someone like myself, walking round the university all day, would never spot an invention. It cannot be done. The other part which requires the hard work is the bit after the patent. It is no good patenting unless you have a licence or can put the technology into a start-up company. That is a very labour intensive task. It is this bundle of activities which have to be supported professionally, and not just the patenting process itself. The last thing I want to say is in the same vein; that things like licence agreements are very important to our whole research base. It is part of the research business. More and more academics now are conducting research in the expectation that their work will be put to some use in the future. Therefore, they are interested in the possibility of licensing or company formation in the longer term; even if they have not thought that through very explicitly, they have a consciousness that that is an acceptable and desirable thing to do. Secondly, if you are successful in licensing that is one of the most significant triggers for further research that you can get from the company. Often, with a licensed technology, that is the start of a very long relationship with that company, and often—sometimes—millions of pounds worth of extra research funding will flow from that company into the university.

(*Dr Thomas*) I am David Thomas, from Imperial College's technology transfer company. Until last September I was also in charge of the administration

of research. I retired from the college at that stage, but I am still running IMPEL, the technology transfer company on a part-time basis. May I say I agree totally with what Hugh Thomson has said. The problem, as I see it, is that there should, in each university that has a significant portfolio of research, be a technology transfer unit of some sort, with the sort of expertise in patenting and licensing that Hugh has mentioned. The company can advise and work with academics who provide world-class research through its technology transfer executives who understand better, perhaps, than the average academic how to exploit the results through to industry. The problem, I think, in a national sense is that the technology transfer function is under-resourced. To put numbers on it, at Imperial College, at the moment, we are in the process of merging with medical schools in West London (as Lord Winston will know only too well) and that means that we will have something like 2,000 academics. There are currently five technology transfer executives trying to help those 2,000 academics market, and that is just not enough. Doubling the number would make a significant difference. Imperial College has been extremely generous to its technology transfer company in getting it to the stage it has. More could and should be done. The top ten American universities do very much better than United Kingdom universities, and this can only be because the technology transfer units of the latter are not as strong.

Lord Flowers

304. That means it is a problem of scale?

(*Dr Thomas*) It is a problem of scale in technology transfer, yes.

(*Dr Robertson*) I am Douglas Robertson, University of Nottingham, Director of Research Business Services. Again, I would like to echo Hugh Thomson's sentiments. The key in the process is imbedding the innovation or the technology function within the academic community; not necessarily seeing it as something that is done to academics but as something that academics undertake and wish to be involved in. When one looks at the figures in the United States, some of that is a matter of scale in terms of the research income against royalty income. Within the United Kingdom in many universities the percentage relationship may well be the same. The key, I think, as far as the United Kingdom is concerned, is to look at it in macro terms at the United Kingdom level as to the investment in, vis-à-vis the revenue out. At the moment my concern is that too often we are trying to tackle things at an individual project level, and the only way you can solve it at project level is to over-resource it. Therefore, resources need to be made at an institutional level but assessed against performance across the entire system. You can invest a great deal of funding in technology transfer activities and never get a successful product to market, or you can invest a little and be successful. Therefore, the aim is to have a portfolio managed across the system in such a way that the return to the United Kingdom is significant. One of the other concerns at the moment is we have to approach the intellectual property equation on the basis of the global economy, and the quickest route to market for that piece of technology. It may be there are routes to market within the United Kingdom but they may not be as obvious and will take more resource to find them. Therefore, the level of resource available will, as a matter of course, affect the ability one has to secure a licensee within the United Kingdom as opposed to, maybe, the world leader in an American, Italian or British firm.

305. Could I just briefly ask Mr Mitra a question, because he said something interesting about the role of the former polytechnics and the smaller institutions and the need for them to work on more immediate things so that they would be of interest to small and medium-sized firms. Who pays?

(*Mr Mitra*) A good question. The initial money that is for the benefit of small and medium-sized companies tends to come from European funding. There is less so in terms of looking at programmes of innovation, programme management or, indeed, technology transfer, from the Training and Enterprise Councils, or Business Links, or, indeed, the local authorities and, of course, central government. I think it is a combination of the two. What we have found through working with small and medium-sized companies is that if you are able to generate activities with the help of the public purse they are quite willing to pay if you can actually identify a solution to the problem. We recently worked with a company in London looking at hi-tech printing equipment, exporting from the United States—an isolated company which nobody knew about. We worked with them over a period of three months to enable them to win a SMART award. That has immediately given them sufficient, if you like, investment to be able to launch into activities for which they are paid, at the moment.

Lord Dixon-Smith

306. How important to the funding of your research programmes are licensing agreements, intellectual property rights and research and consultancy contracts?

(*Dr Thomas*) Most of the funds that come in from licensing of intellectual property would be fed back into research. Even in the best universities, if you compare the research income with the income from licensing, the latter is only likely to be a few per cent. That is not to say it is not important. If a university takes a £1 million contract, it costs it at least £1 million to do the research, and this does not help support the university's infrastructure. But licensing income that arises is unencumbered in that way and is, as it were, profit that the university can use to invest in new research programmes.

(*Dr Robertson*) The critical point is not so much those specific agreements but—coming back to the point Hugh Thomson made—the access to results, and having a clear route and manageable arrangement to put around that. Instances will differ from technology to technology. In an embryonic technology where the breakthrough has not yet been made, the background technology would be relatively unimportant. Five years later, looking at

Lord Dixon-Smith *contd.*]

that same research team, it will have changed significantly and the intellectual property may be the fundamental base upon which all further research income will flow, and unless you have that platform no one would be willing to invest in that technology. We have an arrangement with Zeneca Plant Sciences where the breakthrough was initially made in the late 1970s, the patentable inventions emerged late 1980s and the exploitation happened in 1995. It is now going forward in 1996 and 1997. So it is a long-term campaign and it does matter, but it matters in different degrees and at different points in the process.

(*Mr Thomson*) Contract research within industry is increasingly becoming an important part of our research portfolio, and our ability to bring forward our intellectual property—which is not just patenting but also is know-how and, sometimes, copyright—in a business-like way, to put before potential industrial sponsors, is very important to them. So, having intellectual property is the base of a lot of our research contract work. Then, the agreement you have with industry will often contain an option for the company to take a licence to that background if they require it further down the road. If I may also add that at Strathclyde University we are quite fortunate in the fact that we earn quite a bit of money from licensing, and the university uses a good proportion of that to invest back into the academic strengths of the university. So there is a virtuous circle in which we encourage those parts of the university which produce the best results.

307. Can we explore the virtuous circle a little further? Lord Dainton will remember we ran across this in the United States where there was a clear practice across a number of universities (and we had the impression that it was general) in which the university, if you like, held the intellectual property rights, the originator of the idea usually held the licence to manufacture and went off and established a commercial company, and, of course, the university benefited by the feedback as a result of that commercial development through royalties into its central funds. It was remarkable how often, in fact, at every academic establishment we visited, this was a common feature. Is this becoming generally accepted?

(*Mr Thomson*) We regard that as the norm. There is the royalty income that comes back in. There is a sliding scale, but on average we give half of that back to the academic inventors. The university retains the other half and that income to the university is the nearest thing we have to profits; it is not earmarked for any particular purpose so we invest it freely.

308. Is it a condition of employment that is fixed for everyone, or is it negotiated in each case?

(*Mr Thomson*) The rate of return to the academic is fixed. It is a known formula. I might say we have one or two millionaires on the staff as a result of that process.

309. But in America the originator of the idea would actually be the man who made the most. Is there not a fundamental difference?

(*Mr Thomson*) Sometimes. That is more often the norm on the East Coast of the States where there is a larger number of academic staff who get involved in setting up their own companies and earning the return on the intellectual property directly. That phenomenon is less commonly encountered in the United Kingdom.

310. One of the areas that interests me most is this cultural difference that we appear to have. There is a tendency here for academics to regard themselves as academics and not see their, if you like, potential involvement in entrepreneurial activity.

(*Mr Thomson*) I would like to suggest that is changing.

(*Dr Robertson*) I would like to echo that. I think it is changing. I think the part of the process is back to embedding the technology activity within the academic community and getting them more aware of the opportunities that might avail themselves of their technology, but we do have a system which of itself reinforces that culture of academics being academics. We judge them on their academic quality and their academic integrity. Therefore, one has to be mindful of what the system passes judgment upon. I would think that although there are more companies of that type in America against the total size of the system, it merits some consideration.

(*Mr Mitra*) Just a slightly different dimension, but relevant to the question, I think, is the reliance that the universities put on consultancy contracts to build up a research portfolio. That is number one. I think that is quite significant for universities. Also related to that question is how we also work with other, older universities which have a high research profile. Our university, for example, has a very strong protocol arrangement with the University of Bologna—which, incidentally, claims to be the oldest university in Europe—which looks at IPR and more pure basic research to be their forte in certain areas, and for us to work on the more applied side of it relating to the same subject areas. We are finding a very interesting combination in terms of working with them to meet the needs of mainly companies, interestingly, in the United States, but also, increasingly, in Britain.

(*Dr Thomas*) If I could come back to the question of start-up companies. It is my perception that the academic workforce has recently become far more interested in start-up companies. There have been some notable successes in biotechnology. The climate has changed in the last ten years, with people moving out of academia and becoming the principal driving forces in start-up companies. That is good news, I think, because it does mean that lots of small businesses will be created.

Lord Dainton

311. There are tendencies here and there for research granting bodies to insist on clawing back something like 1 per cent or imposing a charge to protect rights. Have you come across that? What is your attitude towards it? Should Government funds be specifically earmarked in any way when a grant is made? The Natural Environment Research Council is cited as one.

(*Dr Thomas*) Can I comment? I think the royalty share is now accepted between the sponsor and the university quite widely. We have occasions when a

company will say "We cannot afford to pay the whole cost of this research but we will share it with the university", and then an agreement can be reached on sharing any exploitation income that arises from the work.

312. What happens if the sponsor is not a commercial company?

(*Dr Thomas*) In the case of charities, they are becoming interested in sharing the revenue. One can, and does, strike such deals with charities now. The research councils do not, of course, require to share royalties at the moment. In general, I think that is fine. The return can be, as it were, via the chain of the company making a profit and paying it back into the Treasury and the Treasury awarding it back to the university. I am comfortable with the fact that the university would not have to pay the research councils and share with them.

313. Are you also comfortable with any kind of discipline (I do not know whether it exists) which might be imposed upon yourself that you pay a share of whatever revenue is made through the summation of the arrangements which you are able to come to with external companies?

(*Dr Thomas*) My company, IMPEL, runs on a commission basis in which it retains 30 per cent of what it earns. Over the last ten years it has paid its way.

314. Would you recommend that as an incentive to everybody?

(*Dr Thomas*) I think it is possible to do it, yes. A technology transfer company should run as a business. I agree totally with Hugh, it has to work in support of individual academics, but I do believe it is a business which should be run as a business. Its object is to make money, and therefore it should be clear from the outset that it should be aiming to do so.

Chairman

315. Does any of you feel there is a need for the research councils to, as it were, themselves "cream off" and support the process of technology transfer with some specific percentage?

(*Dr Robertson*) At the moment the MRC invests in technology transfer within its own institutes, but interestingly it does not provide resource tied to their funding to allow universities to exploit the benefits of the particular piece of research or the breadth of research funded by that particular agency. I think it is important to avoid chopping it up into too small pieces. There is a danger of everybody believing that they should be involved. I think sometimes one has to look at it at the macro level and ensure it is viewed as the system as a whole, and the portfolio for an institution and for the country that can be managed effectively. I do not think it would be appropriate as a model for the research councils to seek a return in royalty terms from the funding they provide to universities; it should be viewed as part of the process. We already believe that there is a shortfall between the amount provided for research councils and the amount it actually costs to undertake a particular project. To then have to share the proceeds and avoid those proceeds being re-invested within the institution, I think, would be counter-productive.

(*Mr Thomson*) In terms of an intellectual property office washing its face and operating profitably, (fortunately at Strathclyde University ours does work profitably), from hard experience I would say that for a university wanting to set up an office from scratch it would take, probably, seven or eight years to achieve profitability. University research is distant from the marketplace and in our experience it does take several years for a research result to be commercialised. So a university has to have quite deep pockets in order to set up an office.

Lord Dainton

316. They do the initial long-term investment and then progressively you become self-supporting?

(*Mr Thomson*) At Strathclyde the university consciously made the investment to double the size of the business. It made that investment nine years ago. In the business plan we had aimed to achieve that target in seven years, and in fact it took eight.

Chairman

317. I do not know if you would like to add anything, Mr Mitra, from the perspective of the new universities on this point?

(*Mr Mitra*) If I may add a different dimension to it in terms of looking at self-financing operations which my colleagues referred to. I myself run a self-financing set-up within the university, where we look at issues of applied research connected with training as well as technology transfer in the broadest sense. Our approach is essentially based on the concept that if you were to run anything remotely like a business then it should reflect the business environment—firstly, something which accords with the needs of the business or the client community that we are working with, not only the serving community. Secondly, one should spread the risk a little bit and not just entirely concentrate on research but look at other applications; in other words, have a portfolio of business activities within a set-up. That is an approach that we took in order to, in a sense, sometimes subsidise but, also, to "grow on" existing activity.

(*Dr Robertson*) I am not entirely convinced that the company mechanism adjacent to a university is an appropriate route. It can, on occasions, lead to targeting short-term gain when the benefit may actually be in the longer-term application of that research. If we take a strictly commercial view over a short time horizon we may make decisions that are not in the best interests of the research environment or of the university system or of the United Kingdom. Again, with some of the technologies we have been involved in, if we had made a strict commercial decision we would have stopped research in that area because it would not have produced a marketable product because no one could foresee it. That was the case with magnetic resonance imaging, and it took several parallel technological developments to implement these ideas in the marketplace. If we had made a financial decision then

Chairman *contd.*]

we would not continue researching in that environment because we could not see the product.

Lord Flowers

318. Could we have a few words about the role of the science parks and their relationship with the universities? For example, are science parks something which only a large, research-intensive university can cope with and contribute to? Is there a scale problem? Would the big ones amongst you advise former polytechnics to go into a science park, for example, and deal with some of the problems of relationships with small and medium-sized companies? What are your views about the proper role of science parks?

(*Mr Thomson*) I think it depends a bit on what part of the country one works in. In the West of Scotland we do not have critical mass available in a number of new, high-technology industries. To take opto-electronics, for example, a lot of research is done in Scotland but there is almost no industry to support that. Pharmaceutical or biomedical research in Scotland is substantial but there is not the critical mass of industry. In that climate it is difficult to fill up a significant sized science park with that kind of company; you need a critical mass of people, and people want to feel free to move between companies. We are now looking, in the West of Scotland, at our science park in terms of the extent to which we can attract inward-locating, hi-tech parts of existing companies, who can work with the universities (because we share our science park with Glasgow University) and can employ our graduates. We have found rather more useful our incubator unit, which is pre-science park, which actually operates on the university campus. That has been very helpful in looking after embryonic companies where the managers of the incubator are not so much concerned with paint and clean windows but much more concerned with looking over the shoulders of those small companies and making sure they remain healthy and do all the right things in management terms. So I think in the West of Scotland we have a slightly different view, and I have to say that our science park, although significant, has not been as useful to the university as it could have been. We have learned from that in modifying our strategies accordingly.

Lord Dainton

319. Are the managers of your incubator full-time members of staff?

(*Mr Thomson*) No, they are not. We run the incubator as a limited liability company and attracted a number of founder members who put money in to create that facility. The university is one of four members, so it employs its own staff.

320. So it is a consortium of investors.

(*Mr Thomson*) That is right.

(*Dr Robertson*) Again, I think the perspective of the science parks is they have their place in certain locations and it depends on the attractiveness of them as a location not just in terms of their proximity to universities. If you analyse many science parks, they are not truly science parks, they are business parks that happen to have a number of technology companies on them. They do not necessarily have a close relationship with universities adjacent to them, or which might even own the land. I think the key, from the university perspective, is not the science park per se but the incubator and seeking mechanisms to take the technology from the research stage through what I would call the development gap (and what many others call the development gap) to a point at which a realistic assessment can be made of the level of investment required to create a spin-out company in its own right, which might then locate on a science park. The science parks do not address the transfer of technology from the university into the companies; it is the middle part of the process (the development gap) that requires attention.

Chairman

321. Mr Mitra, would you like to respond to Lord Flowers' question?

(*Mr Mitra*) If I may come to that point from an economic perspective, by and large science parks tend to have become—as I think my colleague alluded to—real estate developments, and the real link between academia and industry in true science parks is highly questionable. In some they work very well, in others they do not, and I think that is the European situation—or even the American one. In London one of the most interesting developments taking place now is about seven potential science parks to emerge. Ninety per cent of them are being championed by the new universities. If you take just four: Greenwich, University of East London, the Royal Docklands and Middlesex University, we are also looking at a specific science-focused technology park. I think the most important thing that is coming out from that is this question of clusters of industries that can be located in science parks, but not just the companies within the science park but how they relate to the problems encountered by clusters—in other words, distribution, the supply side, and the universities' involvement in terms of education, training and research. Not necessarily physical proximity to the actual development but technologically linked to those clusters. That is the concept. More technical consequences seem to be emerging, which is very exciting. We run a project called the London Technopole Initiative, which does not look at a science park in terms of a physical sense but more in the terms of a virtual link, where you actually enable expertise within the university to reach out where innovation really occurs, and not necessarily to assume that innovation only occurs within universities. There is a lot of innovation, a lot of real knowledge based activity, going on in the outside world. That is the kind of linkage we would like to make. The economic argument, in a sense, is predicated upon the value that cluster based economic set-ups can provide for the purpose of economic regeneration in any one area.

Lord Flowers

322. What about Imperial College's experience where it has chosen to put its science park about 200 miles away in Wales?

(*Dr Thomas*) We have two science parks, one near Ascot and one in Wales, which has just been 'gazumped' by the investment by LG International. I have to say that one of the attractions which brought LG to Wales was that Imperial College was part of the team. Although we are surrendering a lot of our real estate there, to our advantage, we are doing it willingly because it has succeeded in bringing a very large investment to the UK. I think it is the biggest inward investment that has been made in Europe. London has of course got a problem because the nearest science park is 45 minutes driving time away and that means that the academics have problems getting back and forth, not like in Cambridge, for example, where you can get on your bicycle and go down the road. There is a special problem in London. I do not think it is too difficult to find accommodation for science parks in other areas. I would not put it very high on the list of priorities for what a university has to do to succeed in technology transfer.

Lord Cuckney

323. May I ask about the funding of incubators? In Strathclyde's case, it sounds as though they are joint ventures, externally financed.

(*Mr Thomson*) Yes. The university provided a derelict building and others provided the finance to make it usable.

324. May I ask if that is the same with other universities: that incubators are financed as joint ventures, or are they internally financed?

(*Dr Robertson*) The incubator concept as such can actually be managed in a devolved research environment to tackle the development funding phase. It often happens within a laboratory, not necessarily as a distinct physical development in its own right, but we at Nottingham are looking at the concept of a biotechnology incubator. We are at present doing a feasibility study on that and we would be looking for external investment because it is investment which requires people to make a decision on the commercial risks involved and knowledge of the market place. We believe we do that best in partnership with others, rather than trying to second guess the market from our own perspective.

325. On business angels, the use that is made of them and the introductions that you effect to them, we had tabled when we arrived the Strathclyde paper which I have hardly had time to read, but I notice in your case you are quite active in seeking business angels.

(*Mr Thomson*) Yes, we are.

326. And in providing financial advice in seeking start-up funds.

(*Mr Thomson*) Yes. With our start-up companies, we have now used business angels twice. More important than their money has been their willingness and their ability to roll up their sleeves and provide very important management skills in these new companies. What we were finding at the university was that for every one true entrepreneur that wanted to run a company from the front from amongst our academic community, there were another 10 or 15 who were very keen to see their technology put to use and would very much like to see a small company do that, but did not actually want to run a company. They wanted a chief executive to work alongside them. They would put in all the hours to take the technology forward and provide technological support, but they wanted someone else to run the company. We were finding it much more difficult to find these chief executives than it was to find the start-up funding. We turned to the business angel community in Scotland and I addressed one or two groups of them to see whether there would be anybody interested in working alongside academics at the pre-formation stage, when you have got intellectual property, a patent or two, and you are trying to work out how best to exploit maybe a start-up company, maybe a joint venture, maybe a licence, and asking business angels to get involved at that stage. A significant minority said that they were interested in getting involved at that stage.

327. You have not actually found it difficult to find business angels?

(*Mr Thomson*) No. They are quite numerous. I was surprised how many there were, in Scotland in particular.

Lord Flowers

328. What is in it for them?

(*Mr Thomson*) I think two things. Firstly, they are interested in investing their money with the usual tax advantages that they can obtain, but for this minority it was an interest in getting involved in a new idea, a new company. Some of them are quite young. They have made a lot of money from a high-tech company. When they have been bought out, they have moved out because they did not want to work in a larger company. They are very keen to start again. What they lack is the idea, the concept. From time to time, it would seem that academic staff could be a very useful source for them.

Lord Cuckney

329. These are serial entrepreneurs?

(*Mr Thomson*) Yes.

Lord Kirkwood

330. How are they identified?

(*Mr Thomson*) There are small offices in Scotland that represent groups of them and they act as a kind of broker. We approach them through the offices.

(*Dr Robertson*) Within England, many of the business angels can be identified through various banks and accountancy organisations that tend to have their own network of individuals that they may have counselled and advised through their first investment, through their second investment. Then they realise that they are potentially serial entrepreneurs or serial investors. I think it is a developing phenomenon. With business angels one

Lord Kirkwood *contd.*]

can find individuals but often they do not just want to make an investment; they actually want to have something that they have an interest in, the technology, and therefore it is often a marriage not just of their financial but of their technical interests that you have to accommodate. That means that it can be quite an intensive process sometimes to make that marriage. We have one or two that are close to specific departments and they are particularly interested in environmental technologies that are green. That is the reason they wanted to make the investment in that academic team. It was not just a straight financial return; there were other factors which they were taking into account.

Lord Dixon-Smith

331. As a matter of financial return, do these investors tend to see the attraction of this as coming through the revenue that will be generated or do they see it coming through capital appreciation or an equity participation?

(*Mr Thomson*) I think the latter.

Lord Dixon-Smith] Do they run into obstacles in this particular way or not?

Chairman

332. Are the innovators resistant?

(*Mr Thomson*) Are the universities resistant? No.

Lord Dixon-Smith

333. Or the originators of the idea?

(*Mr Thomson*) Occasionally, you meet academics who will not wish to part with any equity at all, but mostly we work on them and advise them of the commercial realities.

(*Dr Thomas*) We trust that the sensible ones will surrender some of their equity because it is much better to have 50 per cent of a lot than 100 per cent of nothing.

(*Mr Mitra*) Just a slightly different slant in terms of business angels. We are beginning to use business angels in a slightly different way by actually involving them with students, specifically in entrepreneurship and innovation management programmes. The purpose is two-fold. One is to build on the links between industry participants actually engaged in academic involvement, if you like; the other is also to identify potential business possibilities based on student research and academic work.

Lord Dainton

334. Are you saying that in fact these business angels get involved in the teaching process in appropriate subjects?

(*Mr Mitra*) I would not say so much the teaching process directly, but more in the tutoring and tutorial processes.

(*Dr Thomas*) I was just going to comment on another dimension, on approaching venture capital companies. There is a problem usually where the academic does not wish to be involved in the management of the company. He is quite happy to be involved in it, but wants somebody else to manage it. In approaching a venture capital organisation, one can frequently get them to suggest a manager, as they have lists of available people. We have found that quite a useful way of tapping into potential managers who may be very skilled but who may not have the capital to invest in the company themselves.

(*Dr Robertson*) In response to Lord Dainton's comment, the University of Nottingham has piloted a programme with other universities on biotechnology for business, which is a student based competition, where the individual student group tries to take an idea through from idea to market place in a business plan. We have involved business angels in tutoring that part of the process, in bringing their expertise to bear so the student teams can develop from that. I think that is a key part of the process. We have to build the entire cycle through the undergraduate, the post-graduate and through the senior academic community. It is not something where you would pick off people as they emerge with a bright idea. The environment has to be created whereby they are looking for the idea and they have opinions about how they wish to take that technology forward. It is again embedding it into the academic community, not somehow viewing it as something separate and tainted.

335. As you know, there are something like 22,500 contract researchers in science, engineering, technology and medicine at the moment in the universities, not a happy state of affairs for some of them. It does seem to me that there is an opportunity for people like yourself here to begin to interest that group in their own self-advancement. Have you recognised this as a possibility and, if so, are you doing anything about it?

(*Dr Robertson*) We have recognised it as a possibility. Most definitely. It is not just a fact of life for contract researchers; it is a fact of life for employment in any advanced economy, where flexible working practices and contract research are the norm rather than the exception. Most definitely, again, it is resource dependent but that represents a significant pool of expertise that is probably not being effectively tapped yet. Various individual projects are being pursued in that area but there is probably much more that can be made of our resources.

Chairman

336. Could I ask you, just in a final, very brief response, if there is another single point you would like to raise with this Committee?

(*Dr Thomas*) There are lots of occasions where researchers come and say, "What we really need is more money to do research", particularly in fast moving areas like genetics. We will try and get venture capital into that area, even though venture capitalists in general do not support research. In fast-moving areas, the difference between research and product development cannot be clearly drawn.

(*Mr Thomson*) I would like to say that where universities provide professional, proactive services in the area of intellectual property, patenting and

Chairman *contd.*]

licensing, I think it is far more beneficial that the intellectual property should reside in the ownership of the university than in the individual staff who, individually, do not necessarily have the experience, the ability to negotiate or the understanding of the legal processes.

(*Mr Mitra*) One important point that perhaps I would add is that if science and technology is going to be converted to innovation and there is an inevitable distinction between the three, then perhaps alongside, looking at technology transfer issues and intellectual property, the strong encouragement of entrepreneurship and innovation studies and research activities within universities, students and staff, is strongly recommended.

(*Dr Robertson*) I think we often tend to do ourselves a disservice by believing that we are bad at something. We may be not as good at some things that we wish to become better at. The environment in the university system is becoming much more professional. The academics themselves are becoming much more professional in the way they manage their research businesses and I think there is much more that can be done but, in strict terms, there are investment decisions that have to be made on the back of that if we are to capitalise on the academic knowledge base of the United Kingdom.

Chairman] My thanks for coming at such short notice and for responding to our questions in such a speedy and efficient fashion.

Memorandum by Professor Gareth Roberts

I am pleased to contribute to the enquiry on how innovative ideas from our science and technology base are turned into exploitable products or processes for the United Kingdom. My views are based on my experiences in four universities and two industrial companies.

1. *Introduction*

At a Conference on 10 December, the President of the CBI spoke on the theme "the next 15 years in British industry". In this speech he said:

> "In industry we have been encouraged by the Government, and by our own requirements to look to the future, to recognise that we are in a time of change, that we are in a period when the rate of change is going to accelerate. It must accelerate if we are to keep pace as an industrial country with our foreign competitors."

At the same Conference a Director of ICI claimed that "The future belongs to the innovator; and the innovator these days has to deploy a formidable team of men and women on research and development, with an increasing armament of costly instruments. These are, I suggest, some general trends discernible in research. In pure research, the pursuit of knowledge for its own sake, I would expect to see a decrease in relation to the whole. Research directed at specific objectives will absorb, and I hope satisfy, most of the available people entering a research career."

An important contributor to the same Conference was Brian Flowers. I quote from his speech:

> "The cream of research scientists, I suppose the top one per cent of them, will always do whatever interests them most, for reasons that may be obscure even to themselves. But the vast majority of us, the remaining 99 per cent or so, are prepared, and I suspect would be happier, to have our work guided into channels that look promising rather than channels that look unpromising."

This Conference on Industry and the Universities was held at Senate House on 10–11 December 1965 when I was a young lecturer at The University of Wales and Lord Flowers was Langworthy Professor of Physics at The University of Manchester! Over 30 years later we are still struggling to find the right formula; clearly some of the faults are still there and need to be addressed by Government, industry and academia.

2. *Managing Change*

Leading any institution is a precarious business; modern Managers, Chief Executives, Vice-Chancellors are working in an increasingly complex environment. Instead of adopting a culture which manages uncertainty by attempting to minimise it, a successful organisation must therefore embrace an adaptive model which prizes a willingness to change. Intuition, Creativity and Innovation must be nurtured and allowed to flourish. The emphasis needs to be on identifying and involving staff who are vigilant to the demands of an increasingly turbulent environment; a need to engage staff at all levels in strategic thinking where the premium is on imagination. Organisations require people who are sagacious as well as intelligent in order to make progress.

In one of his poems Lord Tennyson wrote "Let the great world spin for ever down the ringing grooves of change". Francis Bacon, over three hundred years ago might well have been speaking today when he reminded people that "He that will not apply new remedies must expect new evils; for time is the greatest innovator".

3. *Effective Leadership*

Effective leadership is undeniably a powerful amplifier in the innovation process. Chief Executives and Managing Directors must have a strong personal commitment to innovation and not be averse to risk taking and change. In a large, diversified company it is usually not possible for the top management to have greater functional knowledge and expertise than subordinate management. Therefore good communications at all levels is essential. It is also important that key staff be given time, encouragement and resources to devote to the planning process.

Science and technology are leading forces in defining new business opportunities. They also play a key role in shaping future lifestyles. Therefore technology planning must be fully integrated into an organisation and be intimately connected with other activities such as marketing, design and production.

That said, a survey carried out by the CBI about 5 years ago judged that only 15 per cent of the large firms it surveyed were truly innovative. One reason for this is that financial analysts external to the company put pressure on top management who then place a premium on immediate results. The pressure is then transmitted to middle managers who, not surprisingly, become more action-oriented than planning-oriented.

Innovative individuals are normally highly self-confident and energetic, with a high desire to achieve. They are more likely to innovate when they are performing tasks that are intrinsically interesting. At the same time they need a sense of psychological safety. Where there is great anxiety about job security there is likely to be consequent effects upon creativity and innovation. Successful innovative companies normally exude a culture of improvement and quality, a climate of good communication and a reputation for involving employees in strategic debates.

In summary, a flexible strategic planning process where the emphasis is clearly on innovation coupled with dynamic leadership, can help an organisation to do more than plan for the future. It can also help an organisation to create its future.

4. *DTI Innovation Unit/Innovation Deficit*

The White Paper 'Realising Our Potential' quite rightly points out that 'Firms which are skilful at innovation will secure competitive advantage in rapidly changing world markets; those which are not will be overtaken'. In a recent article in Science in Parliament, the President of the Board of Trade recognises that "Innovation is often about R&D and new technology, but it also involves imaginative management, appropriate finance, a skilled and empowered work force, a deep understanding of markets and a supportive overall business climate."

Edith Cresson, the member of the European Commission responsible for research and education has said recently that she is determined to foster a genuine innovation culture in Europe. She has spoken of an "innovation deficit" in Europe. She speaks about the urgent need to create a real policy for training for innovation which at present seems to be missing from our educational system. She speaks about breathing new life into the patent system and has promised to bring out a Green Paper on this subject this year. Above all, however, she is critical about our lower level of investment in research compared with our competitors. In her words "One cannot refuse to invest in the future and then be surprised that the future slips away."

Overall Europe invests only 2 per cent of its GDP in research. We in the UK are the only major industrial country which has reduced the proportion of GDP it invests in R&D in the period 1981–93. We invest only about half as much per capita as do Japan, Germany and France. The few world class companies in Britain with their good record disguises the poorer performance of the rest who have been consistently investing at a lower proportional rate than their major competitors.

5. *Diversity*

It is, of course, important to recognise that employers are not a homogeneous bunch; the electronics industry is very different to the pharmaceuticals industry; small and medium sized industries, which are so critical to the innovation process, have different needs and problems to the large multinational companies. Similarly, the organisation of research in the more than 100 universities in the UK, varies considerably from the large, strongly research focused institutions to those that are small and teaching focused.

The whole range of research is represented in universities from basic to applied and development work, and from the humanities to the most equipment intensive sciences and engineering. This diversity must be recognised and nurtured.

All Universities operate nationally and many have a strong international dimension. They are therefore obliged to carry out work at the very leading edge of technology. At the same time their development is inextricably linked to the region in which they are based. It is at the regional level that small and medium sized enterprises can most easily forge links with each other, and cooperate with their local universities and business advisory services. Small businesses are crucial to the innovation process and so the regional dimension is very important.

6. *Basic/Applied Research*

The Technology Foresight exercise has been successful in identifying broad research priorities and in generating better dialogue between universities and research users. The shift in emphasis towards more focused research is inescapable, but one that deserves to be pursued only to an extent that does not compromise the essential value of academic research. A recent NAPAG Report emphasises that 'the increasing Government emphasis on practical benefits, must not lead to a creeping displacement of basic science which, by its nature, is far removed from commercially successful exploitation.' We must also remember that in the UK most basic research is undertaken by universities. A healthy research base will be one in which universities retain substantial freedom to determine their own research priorities.

Pressures on research funding are such that no institution can now adopt an attitude which neglects any potential for commercial development, where that exists. Significantly, the latest Research Assessment Exercise conducted by the HEFCE request a tally of patents acquired during the relevant time period and the copyrights.

7. *Basic/Applied Research Balance*

Ian Taylor has claimed that it is not Government policy to divert more public-sector funding into applied research. He has continued to stress the importance of maintaining the level of responsive mode grants. He also recognises that university research is primarily about training people, and about developing new concepts as ideas rather than specially inventing new products or processes.

One of the reasons why more of the research budget has swung towards applied work is the attractiveness of schemes designed to bring universities and industry together. We have CASE awards which encourage industrially relevant research; the well established LINK initiative to promote project based technology transfer from scientific research to UK industry; LINK projects usually support work in universities at the post-doctoral level. We also have the Teaching Company Scheme which supports partnerships between companies and universities for technology transfer and to stimulate the development of graduates for industrial leadership roles.

In 1994, the last year for which I personally have data, there were 2,789 CASE students in the systems, 589 LINK projects and 509 Teaching Company Schemes. In addition about 2.5 per cent of the total Science Budget is allocated to ROPA schemes. One must also remember that basic and applied research were given equal weight in the last research assessment exercise, to ensure that there is no disincentive to institutions in undertaking industrially oriented activity.

Little wonder then that universities have expanded the proportion of their applicable science and engineering research; hardly surprising that we have seen an increase in the number of patents filed, the growth of spin-out companies and support sources for industry.

I suspect that the overall balance is now about right but, of course, there are huge variations between institutions and therefore there is considerable scope for more exploitation of university research.

The statistics for 1994 show that:

1. Research income from external sources varied from £150,000 to £85 million per university.
2. UK industry derived income varied from less than £50,000 to over £6 million per university.
3. Gross income from University Exploitation Companies nearly trebled between 1993 and 1994, with more than half universities reporting that they had wholly owned subsidiary companies for exploiting research and technology.
4. The total number of patent filings during a three year period was in excess of 1,500; these submissions came from 73 per cent of the universities, with the most successful recording a patent income of £9 million.
5. The average number of spin-out companies was about four and about half the universities reported that they had ready access to incubator units.
6. Nearly all universities indicated that they provided a range of specilaist services to industry; in addition a majority ran industry clubs to foster good relationships between regional and national companies.

In my capacity as Chairman of the CVCP I met recently with my counterparts from EU countries to confer about the future prospects for the university system in Europe. It was abundantly clear that Britain was regarded enviously by others in terms of the way it had successfully brought academe and industry together. Persistent underfunding is clearly putting at risk the relatively healthy situation we have enjoyed until recently. We urgently require a strengthening of the dual-support system. If this can be achieved and universities are allowed to retain substantial freedom to determine their own priorities, then I will remain reasonably optimistic about the capability of the university system to contribute fully to the national needs indentified in "Realising our Potential".

8. *Funding of Universities*

A recent report commissioned by the CVCP, HEFCE and CIHE provides information on resources for higher education in OECD countries. It shows clearly that the long image of British higher education as relatively limited in extent, but well financed compared with our neighbours is no longer realistic. There is a prima facie case for concern about the educational standards achieved by at least some UK graduates in comparison with other European countries.

The report by Gareth Williams and his colleagues shows that public expenditure on tertiary education as a percentage of GDP was near the bottom of the OECD league table. Total UK spending on tertiary education in 1993 was 1.2 per cent of our GDP, well below the OECD average of 1.7 per cent. The CVCP in its report to Dearing has argued that the public contribution to HE should be set at a constant proportion of GDP which campares well with competitor countries.

If the UK economy is to remain internationally competitive, it is essential that our universities are adequately funded to maintain the international excellence and standing of their research. However, there is growing evidence that some multinational companies based in this country are re-siting collaborative research overseas in the light of concern about the research infrastructure in the UK.

The CVCP has accepted that research funding should be allocated selectively, taking account of independent quality judgements. Excellence in research, as measured against national and international comparators, must be a primary objective of universities and funding bodies if the UK's research base is to maintain its position in a competitive world.

It is clear that the money allocated by the Higher Education Funding Councils for research is now grossly inadequate to meet all its objectives—to provide the infrastructure for research grants and collaborative contracts, to enable universities themselves selectively to support young researchers with potential and innovative research, and to support postgraduate research training. Many bodies with a user interest in university research are saying that the present level of Government investment is too low.

A recent report produced by PREST concludes that £474 million is needed for high priority research equipment in the next five years. In the physical sciences it is a matter of concern that much of the shortfall is in departments with high ratings for the quality of their research.

In order to sustain the infrastructure for the volume of research now sponsored by the research councils and charities and to enable universities to initiate new research, funding through the funding councils must be increased. Funding from this source has not kept pace with increases from other sources. The balance needs to be improved and a clear indication given of the costs to be borne by each source. In particular, greater attention must be given to the replacement costs of ageing research facilities and equipment.

It is essential that there is clarity about the purposes for which the various sponsors of research—private and public sector, charities and industry—provide their support and the extent to which they expect funding to be provided by Government/universities for the infrastructure. Infrastructure funding is falling between the cracks in the system and none of the stakeholders is taking full responsibility for it.

9. *Technology Transfer*

In a large number of universities, there is an industrial liaison unit which takes the form of a company—usually limited by guarantee and wholly owned by the institution. By this means the unit can operate in a fully commercial profit making environment with corresponding freedom over staffing and condition of service.

The academic community as a major generator of intellectual property has special interest in them. Universities distinguish between a sponsor which is prepared to fund the full costs of the research, including all the universities' overheads, and a sponsor which will provide a lesser level of support. In the first case the sponsor is normally entitiled to exclusive rights in the IPR, subject to the payment of royalties to the university. In the second case the sponsor can expect only a non-exclusive licence, subject to royalty.

Various royalty sharing schemes now operate in universities; a common pattern is for a very high proportion of the initial returns (after making due allowances for the cost of protecting the research) go to the inventor, with a larger proportion thereafter going to the institution.

Patents are costly to obtain and commercialisation depends on success in finding business partners. The main problem is not lack of ideas or a lack of investment opportunities, but a shortage of people expert enough to spot them.

10. *Some Additional Thoughts*

(a) The balance between basic and applied research within the MOD is monitored by the Defence Scientific and Advisory Council, until very recently chaired by GGR. Would there be some merit in having a similar independent body examining the balance of spend within the Research Councils?

(b) There are several examples of good practice in terms of managing the academic-industry interface. Perhaps the OST should carry out a survey of these and produce a booklet advertising them. For example:

(i) The concentration by Rolls Royce of its university based research into a limited number of centres, all of whom are encouraged to network strongly together.

(ii) The "Uncle" and other initiatives initiated by the University of Sheffield which have been spectacularly successful in drawing in SMEs and clustering them into assemblies able to benefit from university expertise.

(c) Given that leadership is such a critical component in establishing an innovation culture in organisations, could the CBI/Institute of Management/Institute of Directors organise courses on this theme and perhaps issue a Kite-mark to those companies it believes to have implemented schemes to ensure the correct creative climate.

(d) Industrial research laboratories are never short of ideas; some they will obviously want to exploit themselves; but the balance could perhaps be developed and exploited via university incubator units. Some modest pump-priming might be needed to accelerate and encourage such alliances.

(e) A critical examination is required of the effectiveness of Business Links and TECs. In some cities they have embraced the universities and are working effectively in partnership with them for the benefit of the region. In other cases there are rivalries and Regional Government Offices are not harnessing the strength of universities, especially in attracting European funds.

Examination of witness

PROFESSOR GARETH ROBERTS, Vice-Chancellor, Sheffield University and Chairman of the Committee of Vice-Chancellors and Principals, was called in and examined.

Chairman

337. Professor, may I start, on behalf of the Committee, by thanking you very much indeed for fitting this session into your extremely busy diary at such short notice. Could I start by asking if there are any initial remarks you would like to make to this Committee?

(*Professor Roberts*) It really is a pleasure to contribute because it is an important subject. I am not a technology transfer expert per se but I have had experience in two major industries and also in four different universities, so it is very much a personal view that I will be putting across. In the documentation I have provided for you, I have actually listed my views under ten headings. The first one is by way of an introduction. It refers to a conference on 10 December when the president of the CBI spoke on the theme "The next 15 years in British industry". I quote from his speech; he said: "In industry we have been encouraged by the government and by our own requirements to look to the future, to recognise that we are in a time of change. It must accelerate if we are to keep pace as an industrial country with our foreign competitors." At the same conference, the director of ICI who was there claimed that "the future belongs to the innovator". He went on to say that he could see investment in pure research increasing. There was also an important contributor to that same conference and that was Lord Flowers. I quote from his speech. He said: "The cream of research scientists, I suppose the top one per cent of them, will always do whatever interests them most for reasons that may be obscure, even to themselves, but the vast majority of us, the remaining 99 per cent or so, are prepared, and I suspect would be happier, to have our work guided into channels that look promising rather than channels that look unpromising." That conference on 10 December was in 1965, when I was a young lecturer in Wales and Lord Flowers was a thriving professor of physics in Manchester, but it seems to me that, over 30 years or more, little has changed. The problems which face us now were recognised a long, long time ago. The second paragraph in my handout refers to managing change, because there is no doubt that leading any institution these days is a precarious business. I think we need to really engage staff at all levels in thinking, strategic planning, where the premium is really on imagination. I think we need sagacious people as well as intelligent people. Quoting from Francis Bacon, who enjoyed these qualities well over 300 years ago, "He that will not apply new remedies must expect new evils for time is the greatest innovator." Another quote for your report! Next in my handout, I go on to effective leadership because I really do believe that, in all businesses these days and in universities, you need effective leadership. It is undeniably a powerful amplifier in the innovation process; it really is. You need chief executives, managing directors, who have a strong, personal commitment to innovation and

Chairman *contd.*]

who will not be averse to risk taking and change. When the CBI produced a report about five years ago, I believe they showed that only 15 per cent of British companies were truly innovative. Having identified the problem, I personally do not think they have done a great deal to try and do something about it. Far too many people are too action orientated and not really planning orientated. We need innovative individuals. They are normally very self-confident people, energetic people, but I think they need a sense of psychological safety, if I can put it that way. They need to work in an environment that does provide them with some job security. Otherwise, I think there are consequential effects on their creativity and innovation. In the fourth section, I refer to the DTI Innovation Unit and the so-called innovation deficit. I am not sure how many of you have seen the January issue of Innovation Technology Transfer, but there is a two page section there by Edith Cresson that introduces this concept of the deficit. I think she is determined to try and foster a genuine innovation culture in Europe. I understand there is to be a new Green Paper this year to breathe some new life into the whole patent system in Europe. Above all in that article, she is very, very critical about our lower investment in research compared with our non-European competitors. In her words: "One cannot refuse to invest in the future and then be surprised that the future slips away." She points out that overall, Europe invests only two per cent of its GDP in research. I then have a section on diversity which I think really is very important. When you question us about the interface between industry and academe, one has to recognise that employers are not a homogeneous bunch. The pharmaceuticals industry is very, very different to the electronics industry. The large, research-led universities are very different to the more teaching-focused former polytechnics. Even some SMEs do not like that label because they claim there are big differences between the S and the M in the SMEs. One I think does have to recognise that the problem is multifaceted. When you are posed a question, then clearly it does depend where you are coming from in terms of what the best solution is. All universities do operate nationally and some, like my own University of Sheffield, operate in large measure on the international front. Therefore, they need to be at the leading edge of science, technology and so on, but it is important, I think, that we recognise that these big, civic universities must also be closely linked to their region. Without them, I believe a region would be a far duller place and a less thriving place. I do have in the handout some excellent examples of how, in south Yorkshire, we really do believe that universities have addressed the problem of linking into SMEs and the large companies. There are some very innovative schemes. Lord Kirkwood is involved in one of them. The materials Technopole actually brings in all the large companies. We have introduced this concept of an UNCLE scheme. Not all small companies like to be in a supply chain. Innovation perhaps is stifled by being in a supply chain, so we have introduced the UNCLE scheme, where a large company or the university itself can actually act as an UNCLE figure for some of the smaller companies. We have a thriving Medilink, which is described in the handout, where we have brought together a very large number of SMEs working mainly in the medical field. There are about 450 of them in Yorkshire. The way we have overcome this problem is to cluster them into groups interested in orthopaedics, for example, and sensors. Via this route they really have been working very, very intimately with the university. I will not go on too much longer because I know you want to ask some questions, but this whole interface between basic and applied research really is vitally important. I believe the shift in emphasis towards more focused research is inescapable but I think we must remember that, in the UK, basic research is increasingly being done by universities. The big corporate laboratories that GEC, Plessey and ICI once had have now gone, so it is so important to protect basic research. When you look at the balance, Ian Taylor, whom I have a great respect for, in the OST, has said that it is not government policy to divert more public sector funding into applied research. He also quite rightly recognises that university research is about training people as well. My belief is that one of the reasons people have swung across to applied research is that we have now these very, very attractive schemes to encourage university and industry to interface together. As chairman of CVCP, I was involved in a big, European conference with my counterparts just a few months back. It was very clear that Britain is way ahead of its European competitors in terms of the way academe and industry interface with each other. We have the excellent CASE award scheme, the LINK scheme; we have the Teaching Company Scheme. The ROPA awards have encouraged interaction as well, so there is really no shortage of good schemes. I do have some statistics on academic research and I am sure you will have some yourselves too. If you examine different universities, the spread is amazing. For example, the research income from external sources in the smallest university is £150,000; in the largest, £85 million. If you look at money from industry, one university has less than £50,000 in terms of industrial monies; another has £6 million. You will find that more than half the universities do now have exploitation companies; they file patents; they have all sorts of spin-out companies; there really has been a change that we can all recognise over the last ten years or so. You would not expect me not to mention the funding of universities, so there is a section in my handout on the funding of universities. I am not sure how many of you have seen the report produced in December by Gareth Williams from the Institute of Education. This compares resources for higher education in OECD countries. It really is a worrying report, because it shows very clearly that the total UK spend on tertiary education was 1.2 per cent in 1993, 1.2 per cent of our GDP, well below the OECD average of 1.7 per cent. The CVCP has argued in its report to Dearing that we ought to see the public contribution to HE set at a constant proportion of GDP, a constant proportion that of course compares well with our international competitors. It is clear if you read Gareth Williams' report and other reports that the money allocated by our Higher Education Funding Councils is now grossly inadequate to meet all the objectives of universities in this country. The infrastructure for research grants and collaborative

Chairman *contd.*]

contracts is effectively not there. Unlike our European competitors, we find it very difficult to match the 50 per cent funding we receive from the EU and of course we have this enormous problem with the charities not providing an overhead.

Lord Dainton

338. These are the indirect costs you are referring to?

A. Indeed, yes. We also had last year the PREST report that I think identified a £474 million funding gap for high priority research equipment. It is really important to point out—and I know some of you round this table do know already—that we are very short of equipment funding. It is ironic that, in a country like Singapore, you can go round even the polytechnics there and find superb equipment. The staff there have fewer good research ideas but have access to this really excellent equipment. The infrastructure is really I think falling between the cracks of the system. None of the stakeholders is really taking full responsibility for it. My last points are to do with technology transfer. Obviously, the academic community is a major generator of intellectual property and has a very strong interest in the way that is handled. You will find many different examples of good practice in different universities showing different ways of handling patents. In my university, we tend to segment patents so that if we have a portfolio linked to the environment or in the area of medicine or in materials we will go to different specialists to help us exploit those patents. I think most people will agree that the main problem is not lack of ideas; it is not lack of investment from venture capitalists. It is really a shortage of people. They have busy lives. You must remember that the pace of change in the universities is enormous. We have the pressure of the research assessment exercise, the teaching assessment process, the whole change in the way NHS funding is handled, the European Framework 5 initiative that we are planning for. There is so much pressure on academics now; storage of time is one of the reasons why they do not get involved so much in exploiting some of their ideas. The final section provides some additional thoughts on the balance between basic and applied research. I have recently given up a four year commitment with the MOD. I have been chairing the Defence Scientific and Advisory Council for Michael Portillo. My committee was really the watchdog examining the balance between basic and applied research in the MOD. I just wondered if there would be some merit in having an independent group of that kind, monitoring that balance within research councils and perhaps the way universities spend their money. There are several examples of good practice across the university sector in the way industry invests in universities. Rolls Royce I think are one of the key examples here, where they have decided that they are not going to invest in more than about eight universities and have established a series of well networked university technology centres. That really is an excellent way forward. I have also mentioned the UNCLE scheme in Sheffield. There are similar good examples in Strathclyde, as you have heard, in Manchester and elsewhere. Given the great concern I have over leadership and the fact that the DTI have identified this as a major problem in the innovation process, I just wonder whether the Institute of Management, the Institute of Directors or the CBI, could perhaps establish a kitemark in industries to find out whether they have the appropriate cultures in place to encourage innovation.

Lord Flowers

339. People are always telling this Committee that the UK science base is very sound and the weaknesses in the innovation system lie elsewhere. We will deal with "elsewhere" later on in the questioning, but do you agree that the UK science base is very sound or do you think that it is under threat—you obviously do, because you said so—from a shortfall in funding? Surely the effects of selectivity, which is the weapon chosen to prevent the funds from being a shortfall everywhere, have led to a situation in which the non-research intensive universities cannot really participate meaningfully in the development of the science base and the innovative process, or is that not so?

A. First of all, Lord Flowers, I think you will understand that I definitely believe there is a threat to the science base due to a shortfall in funding. The CVCP has accepted that research funding should be allocated selectively. When you see the financial allocations to universities announced tomorrow, you really will be surprised at how much shift there has been as a result of the last RAE. I am pleased to tell Lord Dainton and Lord Kirkwood that Sheffield has done remarkably well. We have actually increased our research income by 11 per cent.

340. Universities like yours are earning more and more from non-governmental sources.

A. Indeed.

341. Why should not that process continue?

A. I think there is every reason why it will continue.

342. Why should you talk about a shortfall?

A. So much money these days, whether it is from the NHS or the European Community, is given on a matching basis. Unless we have adequate funds from the Funding Councils that are not earmarked for particular initiatives, then we are just not going to be able to provide the gearing that these other agencies are looking for. We certainly need also to have plenty of money for seed corn research, because there is no shortage of good ideas, as you know.

Lord Dainton

343. But in the science and technologies there is a fundamental problem, is there not now, with out of date equipment for research?

A. There is a major problem. The multinational companies in this country are looking elsewhere. There is no doubt about that.

344. They have given evidence to us indicating that is the case.

A. There is a threat there.

Lord Dainton *contd.*]

345. How is that to be redressed? You will lose momentum in what you want to do in this particular field of exploiting university ideas if in fact the base for those ideas is weakened.

A. There has to be an adequate overhead attached to every research grant. If that means fewer research grants, I think so be it. I believe that is one message that the CVCP has really signed up to.

Chairman] So you would support even greater selectivity than we have arrived at this point.

Lord Dainton] But what would be the criterion of selection? Is it selection by institution or is it selection by ideas and quality?

Chairman

346. And sector?

A. I think the way that I believe Sir Ron Dearing is moving with his group on research is very much in accord with the way the CVCP has been pushing. That is, we must reward good research where we find it. I do not believe we will see certain universities being excluded from bidding for research money. One has to accept that there will be certain pockets of excellence. If people are very isolated, then they should be encouraged to form partnerships with other organisations and perhaps even universities should form collaborations. We, in Yorkshire, have formed an alliance between York, Leeds and Sheffield. It is a very powerful research axis which bids for Faraday centres and so on, with all three institutions working together. I am sure that is the way forward as well for the smaller institutions.

Lord Dixon-Smith

347. Listening to what you have just said is there an argument which says that institutional identity in fact is an obstacle to progress? Do we need to become much more flexible in our attitudes to, if you like, the integrity of individual institutions and start to regard what I would call the boundaries of these institutions as something that need to be much more flexible?

A. Where it makes sense, that is already happening. In Sheffield, my own city, there are very strong links between Sheffield Hallam University and Sheffield University, where it makes sense to collaborate. This is mainly on the teaching front and in one or two key research areas, where Sheffield Hallam is strong. There is no doubt that these two institutions are totally different in terms of the way they operate. One is very research focused; one is more teaching focused. As you know, in any competitive environment, the best way to survive is to form strategic alliances. That has been happening, but each institution would like to retain its individual identity. Within institutions, the barriers between departments have started to break down of course. You find far more multi-disciplinary institute, and research centres and that is a very healthy development. I suspect most universities now would still prefer to keep their own identity and, depending on whether it is teaching or research or consultancy, to form alliances with other people.

348. To change tack just a little bit, there is an eternal problem because of course technically innovative ideas that come out of research do not always come out of what I would call the great research establishments. Are you satisfied that the mechanisms will, if you like, defend the opportunity for the brilliant researcher who pops up somewhere near Land's End, let us say, as a matter of example, to develop his opportunity and ideas against a background where we are seeing what you are saying, a tendency for the concentration of research funding?

A. I think there would need to be some messages put around that an isolated researcher like that needs to find some uncle or aunt to link into. It is perhaps dangerous to have people too isolated, especially in science, technology and medicine. I believe that Ron Dearing will be looking for mechanisms that will perhaps sort out the funding, because there is no doubt that funding methodology can be a block to collaboration. He is going to have to be very clever to ensure, if there is a group in university X that needs to link in with university Y, when they are put in jointly in a research assessment exercise bid, for example, that the money will flow proportionately between the two in a fair minded way.

Lord Winston

349. This is all very well but surely is there a conflict here which one cannot get away from, which is that you have admitted—and I think we all agree—that there is a real problem about approving places, particularly in laboratories. We are talking about technology here and selectivity implies that you have to place that technology in limited places. No amount of collaboration can get across that. This does not really answer the question.

A. If you have one or two good researchers in university X and the real equipment base is in university Y, you could compel university Y, if they are receiving large dollops of money for equipment, to have these people join their teams. Obviously there needs to be quality monitoring here; you cannot allow just anybody access to the equipment, but maybe there is sense in collaborating and bringing these people in. I agree with you totally; equipment is so expensive these days that you have to have research foci; they already exist.

Chairman

350. They do have to have a physical location, do they not? You cannot exactly put them on a bus.

A. No, but the BBSRC, the EPSRC, even now when they allocate grants for large microscopes and the like, definitely make it possible for researchers in other organisations—

Lord Flowers] In some subjects this has been going on for decades. We are all used to it.

Lord Winston

351. In biotechnology, it is not happening enough.

A. I do not know enough about the biotechnology situation.

352. [*Not used*]

Lord Cuckney

353. To what extent do you see the role of the universities as one of supplying research options for industry?

A. I used to be director of research for Thorn EMI. My view there was to link into universities where there really was synergy, where there was real benefit. Any industry that cannot find a few universities to plug into is not being led correctly. I am sure a good industrial laboratory does recognise that linking into high quality research in British universities provides enormous benefits. In Thorn EMI, I did a little bit more than that. In corporate research labs there is an abundance of good ideas. Not every company can exploit all those ideas, so we were more than happy to give our excess ideas to universities. You could let them develop and exploit these ideas in their incubator units, wherever it was most appropriate. Enlightened industry I think already takes advantage of universities, but equally well universities do need to take advantage of the skills in industry too. So often I have seen small companies emerging in a university, where the inventor says, "I can manage all this. I can be the chief guru" and yet he or she has never managed a business before. They should simply become the chief scientist or the technical director and have other people managing the business side of their unit. That is where I think a partnership with industry can be very, very valuable.

Lord Winston

354. How great is the risk that the universities, in seeking commercially and financially beneficial connections, are putting basic research at risk?

A. Clearly, this needs to be looked at carefully. There perhaps needs to be an enquiry within certain institutions, as to whether they have the balance wrong; because there is a temptation if money is easier to come by from a certain route to perhaps get things out of balance. Overall in this country I suspect that we are just about right where we are now. In most of the universities I link into, there is an awful lot of good, basic research, but equally well good applied research. I think with basic research it is so important that it be research that again is applied in one sense, that is that people are waiting for the results. Whenever I did basic research, I always said to myself: "Who is interested in the output of this basic research?" Not necessarily a company, but is there another research group in America or wherever that is. Gradually academics have picked up that message. They just do not carry out research aimlessly: they do have some foresight and try and plan for their research to be relevant in some way or another. The whole interaction between university and industry is a very healthy one in this country compared to what you would find in Europe. One of the major problems is the linkage between corporate laboratories in industry and the divisions of an industry. The corporate laboratories are gradually shrinking; they were the ones that were linking into universities. We might have to do some extra work, to encourage more product-orientated divisions to link into universities. That could be a problem. But, as we know, there is already a tremendous problem within industry, within the corporate laboratory, in persuading the chief executive and the product divisions to invest in their ideas. That is as much a problem as universities trying to exploit their ideas.

355. The problem of academics possibly being reluctant to engage in commercial activities and to start their own companies or become entrepreneurs, to what extent do you think that further development of incubators can help?

A. In my experience only a certain percentage of staff, even in an engineering department, are actually interested in forming their own companies; let us say, one third. It is of that order, I suspect. In most universities that I know of, there is some route to enable them to exploit these ideas. We, in Sheffield, are building a special unit right next to our engineering department, which will be full of incubator units. It is being done in partnership with British Steel and we are providing the land. They are providing the building but it will revert to us in 20 years' time; in the meantime we will share the benefits from those incubator units. In the past we have distributed our various start-up companies around the City of Sheffield and beyond. But now we will have the attraction of one single building, which hopefully will thrive. We are going to concentrate on certain areas like the medical, environmental, and materials fields. I am sure the initiative will give a boost to staff to think: shall we innovate more?

356. But your approach to incubators is essentially a partnership approach?

A. Absolutely, yes. Universities cannot easily defend their patents. In Sheffield we file provisional patents very quickly. Then we ask staff within two or three years to find an industrial partner, a commercial partner, who can share the risk with us. After all, if a patent is successful, half a large pot is still a large amount of money. We are quite happy to share some of that equity.

Lord Kirkwood

357. I am in the unusual position of putting questions to my own Vice-Chancellor! You obviously have a concern about the division of basic and applied research. There is an emphasis now on what is called "managed projects", the "project-based economy" in the terms of this question. Do you feel this places an excess pressure to earn income from this source, and does that damage the other sort of investigation which is initiated by the researchers themselves, and from which probably a lot of the interesting ideas come out of in the first place?

A. There are dangers. Clearly, if we saw an end to the present support system, and money was transferred from the funding councils to the research councils, although people might say we will continue to put a lot of our money into the responsive mode, I suspect that could be the thin edge of the wedge and we might end up having far too much direction from the research councils. That is clearly why it is essential that there be a pot of money in the funding councils which is distributed within universities through the Vice-Chancellor and his or her committees, they would ensure that there is seed corn money for new ideas, for the young members of staff and so on. So there are clearly dangers here. I just wonder whether, as I said earlier, there might be

Lord Kirkwood *contd.*]

some merits in having an independent group who once in a while did look at the balance of the system as a whole, as I used to do with the MoD.

358. Your feeling is that it has gone too far?
A. It is possibly just about right.

359. It could be too right!
A. But with all the momentum which has been generated it could soon be out of balance, I believe, especially given the shortage of funding.

Lord Dainton

360. I got the impression today (for the first time in any of our meetings) that, in a sense, this Sub-Committee was unnecessary; that all was well in the innovation-exploitation zone; that there was no barrier. Now is that true and do you therefore expect within five or ten years' time, that Britain will be the Silicon Country, as it were (you know what I mean by that) of Europe? Because if that is so, that is splendid; but many of us have a strong feeling that this is not so and there are problems. I do not get a complete feeling that what is going on in the universities is so effective as perhaps has been described. What are the weak points that exist at the moment which need to be put right—for example, in relation to industrial liaison officers and the jobs they have to do? Are there lacunae here which are very serious?

A. Industrial liaison officers were very much in vogue 15 or 20 years ago. Most universities appointed them. Gradually, as more and more of our monies have come from external sources, most of the better universities have repositioned themselves. Vice-Chancellors have become far more hands-on in terms of managing their institutions. External linkages are not just left now to the industrial liaison officers. In my own university, the industrial liaison officer is not as senior a person as David Thomas is in Imperial College, for example. In Sheffield, we manage our external links with industry in a rather different way from Imperial College. When I was at the University of Durham, we managed our links there in yet another different way. So there is not a single formula. The title "industrial liaison officer" is out-dated. I really do believe it is out-dated. You need teams of people now to manage that external link with business, with commerce. I cannot remember the figures exactly, but when I first came to Sheffield six years ago, about 87 per cent of our income came from Government. Now it is down to 47 per cent, so that calls for a different structure. You just cannot leave it to an industrial liaison officer to manage a very, very important part of your income. I suspect that when you look at the figures and you find some institutions are performing well, and others are not, it will largely be dependent upon the structure within the organisation. This is a terrible thing to say from the Chairman of the CVCP, but too much democracy does not really work. You need to have firm leadership; you need to consult people and obviously listen carefully; and then go for it and display powerful leadership. In some of the institutions that will be reported tomorrow as not having done so well financially, it is not the quality of the people *per se* in those institutions that are at fault. It is the way they are organised. 361. [*Not used*]

362. That is a splendid essay but I wanted to ask you what your opinion was of the system in Britain generally. Are we overcoming the kinds of problems which are summed up in the title of this Sub-Committee? Do you believe that this is the case, or are there additional measures which should be taken or we should recommend?

A. If you look at the two extremes: first of all the university end, as I have said earlier, the average academic is so over-stretched these days in terms of responding to the enforced change that the environment produces for him—for example, the Culyer report in medicine, the European initiatives, the teaching assessment, the research assessment exercise—they put priority on those issues and not on how to exploit their work *per se*. If the funding problem could be solved in the university system, if staff/student ratios came back to where they were even five years ago, then there would be more time for academics to think about this aspect. At the other extreme, the analysts in the Stock Market have a great deal to answer for; they put unbelievable pressure on chief executives in industry resulting in short-termism. I saw it in my own company in Thorn EMI. I have seen it in other companies. The chief executive is under extraordinary pressure—not from his research director or technical director—but he has to respond rather more to what the Stock Market is saying. So we have to get that sorted out. That is not my problem obviously, but it is a problem in this country that you do not necessarily see elsewhere.

363. If that were right, are we already well placed with the structures we now have in universities to take advantage of a changing situation?

A. I believe so. With the freedom that Vice-Chancellors have now to act as chief executives, they can put appropriate structures in place to form these alliances with certain industries and so on. I am not saying everything is right, but largely it is because the Vice-Chancellors themselves have not perhaps put the right structures in place. One also has to look internationally. We have an office in Japan, in Africa, in Brussels. We do try to exploit our ideas internationally. However, it really is down to the Vice-Chancellor to make sure that his or her university has the right mechanisms in place.

Lord Dixon-Smith

364. I am sorry, but your remarks just gave me the gloriously anarchic thought that perhaps we should get our universities to become quoted on the Stock Exchange as we see football clubs doing. That might, of course, introduce a salutary discipline! It might also be a useful way of raising money, I do not know! But the serious question that I did want to ask was that going back to what you were saying earlier, about the change that is going on with industrial liaison officers, you are beginning to give the impression that there is, if you like, a cultural change taking place at the top of universities, even at the Vice-Chancellor level, where they are beginning to see themselves as managing directors of a total

Lord Dixon-Smith *contd.*]

enterprise rather than as managing directors of an academic institution.

A. Indeed.

365. Am I portraying the situation that is generally happening or am I taking a selective view?

A. No, I think what you are saying is perfectly right. We have positioned our industrial liaison officer, as was, in the Business Link in Sheffield, and he provides us with a corporate radar, if you like. Now, whether all the universities do that, I am not sure. If you will allow me, my Lord Chairman, to express my concern about Business Links, TECs, Chambers of Commerce. There is an awful mess out there, by and large. In some cities, universities have been embraced and the partnerships are working well, but more often than not it really is a bit of a shambles out there, I am afraid to say. There is a tidying-up exercise to do.

366. May I pursue this slightly further; just to say that the drive for this is actually coming from the top management of the universities now rather than from lower down in the machine.

A. Absolutely.

Lord Dainton

367. What about the external financial pressure for money for the university?

A. Yes, that has to be effected too. I chair the important group that decides what the applied research policy should be and so on, whereas I am sure 20 years ago it was the industrial liaison officer who did that.

Chairman

368. Time presses but there is one other related area we very much wanted to raise with you. This is the role of science parks in relation to universities. Do we need more selectivity there? Have we seen a similar fashion to industrial liaison officers and all God's children have got to have their science park? Is this a sensible way to proceed? Does there need to be some consolidation?

A. Again, if you look across the country, there are some very successful science parks which are very different to each other. We know about the Cambridge Science Park. I helped to set up the Science Park at the University of Durham, which is a small focused science park. That is working extremely well. In Oxford, I was there right at the very start of the Oxford Science Park. The Sharp Corporation decided that they wanted to invest in Britain. They expressed the wish to be within a 40-mile radius of Heathrow. They would not have invested anywhere outside that radius. They positioned themselves in Oxford, and that helped Oxford get off to a flying start. In Sheffield we have a distributed science park. You will see from the information that I have left for you that we have a regional technopole, an Environet, we have a Medilink, we have all sorts of initiatives where the pole position, the real node is the university, that is where the hub is, but an awful lot of spokes go out to the South Yorkshire region. We have this virtual science park, as was mentioned by the person from Strathclyde. Now that we have a new building, which is going up right in the heart of our campus, I suspect that this could have quite a formative effect on some of my colleagues.

Chairman] It has been suggested to us in evidence that even science parks on the scale of the best known ones that you have mentioned are too small to give us a pull, a lodestar effect, for international investment in this country. Therefore, we need something on the scale described as the largest, a kind of mega science park—

Lord Flowers] 20,000 acres was mentioned.

369. Absolutely, somewhere in the triangle between Oxford, Cambridge and London, if we are to compete on the world scale. How would you respond to that idea?

A. Not being in that golden triangle I would have to be honest and say I am against it.

370. Wearing your hat as Chairman of the Committee, not as Vice-Chancellor of Sheffield!

A. Again, the majority of the universities are going to be outside that triangle.

371. But you do not like democracy either, so I will not let you off with that one!

A. I do believe there have been sufficient initiatives, I really do. Industry has had the sense to invest in certain universities. Again, if I quote Sheffield. We have an important Rolls-Royce unit there. The British Rail Research Unit is based on the campus and so on. Different companies go to different locations where they can readily tap into expertise. If you just had a very large science park, I am not sure that would really dramatically improve matters.

372. Is there any problem about information flows between universities and industry?

A. No, honestly I believe we really do things rather well in this country and that is one of them. I am trying to think of a supermarket analogy. We have this massive shopping centre called Meadowhall in Yorkshire. But my wife and lots of wives (and myself) far prefer to shop at places other than Meadowhall. Maybe your massive science park would have a bit of a Meadowhall aspect to it. It is the smaller, more select and more focused science parks that might continue to be more successful.

Chairman] Thank you again for coming at such short notice. We are most grateful.

WRITTEN EVIDENCE

Memorandum by 3i plc

EXECUTIVE SUMMARY

3i has extensive experience of investment in technology businesses and believe they represent attractive opportunities for us.

An essential ingredient for success, however, is good management as well as technological advantage. This is usually most effectively achieved by bringing together talented entrepreneurial managers with technological innovators.

The areas which work least satisfactorily are:

(a) the provision of seed capital, although increasing amounts are becoming available;

(b) the alignment of technologists with skilled corporate management.

We believe that there could be room for tax incentives to encourage individuals to invest in technology businesses, to attract corporate managers to work in small technology enterprises instead of large corporations and to attract serial entrepreneurs to retain their capital and their expertise within the UK.

We believe that a closer dialogue between the educational system (at all levels) and the business community would improve the prospects of academic research being exploited commercially.

Technology businesses need to operate in international markets and, beyond a certain level of development, the acquisition of UK technology based companies by larger international concerns may be an appropriate route to exploit global markets. Rather than seeing this as a problem, we should recognise the opportunity it presents to recycle capital and managerial talent.

1. *Introduction*

1.1 3i has over 50 years of experience of investing in a wide range of private companies. Last year (to 31 March 1996) we invested £613 million (including £59 million of third party managed funds) of which 58 per cent went into manufacturing businesses. Many of the best propositions which we see have an innovative element. Whilst innovation can take many forms, in view of the committee's particular interest in technology based businesses, we have restricted our evidence primarily to this topic.

1.2 3i plays a significant role in financing new technologies in the UK and recognises that innovation within the UK industry is a topic of considerable importance. We have already given our views to the Bank of England as part of their preparation of the paper "Financing of Technology-based Small Firms" and have sponsored a CBI report, shortly to be published, on growth barriers in technology-based SMEs. We are therefore pleased to have the opportunity of expressing our views to the Select Committee. We have attempted to restrict our observations to those areas where we have direct experience, which is primarily in the development of new technology by independent businesses.

1.3 We have dedicated investment teams for emerging technology companies in London, Cambridge, Reading and Edinburgh, areas where we are particularly active in this market, but we also actively invest in technology businesses throughout our network of regional offices. Notable 3i-backed technology businesses which have gone on to achieve a stock market flotation include British Biotech, Chiroscience, Meconic, Shire Pharmaceuticals Group, IOC International, Cadcentre and Select Software. Some further information about 3i as a whole is contained in the attached appendix.

2. *What is the current state of innovation in the UK?*

2.1 Innovation is defined as "bringing in new methods, ideas, etc: making changes in:"[1]. 3i is not particularly well placed to comment on the quantity and quality of the raw generation of ideas or of research in the UK, although other sources seem largely to conclude that the UK performs well in this respect. We believe we are, however, well placed to comment on how well those ideas are "brought in" and used to create and grow businesses. Our concern with the state of innovation is therefore less a concern about new ideas themselves and more a concern about the ability to create valuable businesses from what we broadly see as an existing wealth of ideas.

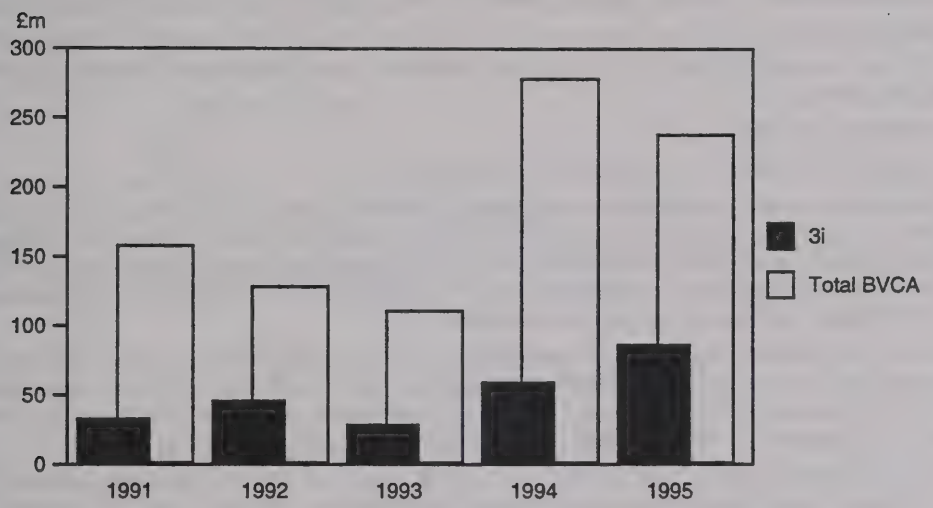
2.2 The BVCA has recently compiled its own data for the technology backed investments in the UK for the period January 1993 to September 1996, which identified 337 such investments covering all stages of development, including MBOs and MBIs. Of these companies 3i was invested in 44 per cent by number. (It

[1] source: Dictionary, Oxford University Press

should be noted that many such investments are syndicated amongst a number of institutions so 3i was not necessarily the sole or lead investor in all these cases.)

2.3 3i has recently undertaken a review of its performance in technology investments in the five year period 1991–1995. For these purposes a technology investment was identified as one where the returns to the investor were significantly dependent upon technological risk. During that period 3i committed over £250 million to 126 businesses in a wide variety of technologies, including information technology, multimedia, biotechnology and telecommunications. This represented over 25 per cent of the total venture capital funding invested in UK technology businesses in a comparable period.

Venture Capital Backed Technology Investments



3i figures are for 12 months to 31 March, BVCA figures are for 12 months to preceding December

Further, it should be noted that the amount of venture capital invested in technology businesses is now somewhat higher than two or three years ago. In terms of new technology propositions being funded for the first time, 3i was investing nearly five times as much in 1995 as in 1991.

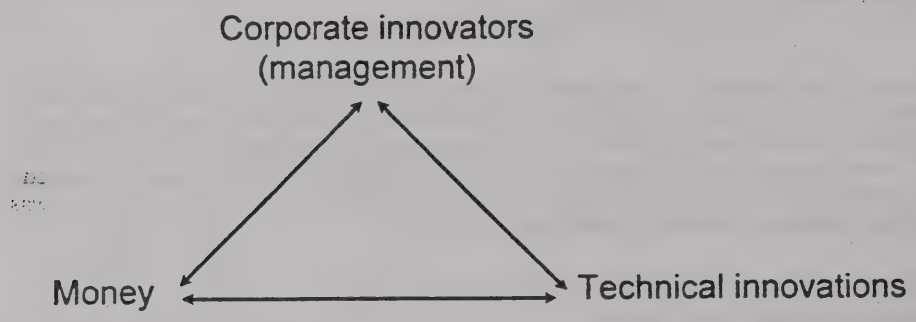
2.4 We do not believe that the returns from technology investments were unattractive to institutional investors and the returns on our own technology portfolio would support this view. The returns do, however, come over a relatively long time scale. 3i is not a closed end fund and has a large portfolio of existing investments. Accordingly, it is better placed to take a long term view than many institutions.

2.5 It is also, perhaps, worth noting that 68 per cent of the UK biotechnology companies listed on the London Stock Exchange had benefited from venture capital funding.

2.6 Over the past few years we have noticed a growing debate about the need to exploit the UK's base of technical innovation more effectively. This is typically expressed as a need to get technical innovation married to funding, or technical innovators communicating well with financiers, ie:

Money ⟷ Technical innovation

2.7 This debate has made less progress than many would like, in our view because it misses an essential ingredient: the experienced managers who are capable of building businesses ("corporate innovators"). The debate is more productively viewed, for us, as how to bring three elements together, ie:



2.8 We do not see any specific evidence of a shortage of technical innovation. Rather, we see a shortage of corporate innovators. To us these people are key to the successful exploitation of a technical innovation in the form of a business.

2.9 We do not believe that there is a shortage of investment funds available in situations where the two ingredients are present of:

(a) corporate innovators, and

(b) technical innovation with potential for exploitation.

Indeed we see an increasing range ofsources of capital available. In addition to 3i and other venture capital firms, AIM, NASDAQ and latterly EASDAQ[2] have become viable funding options for businesses with appropriate promise. The first company to float on EASDAQ was a customer of 3i and Apax, Dr Solomon's Group, which produces anti-virus computer software. We also perceive activity by private investors to have increased significantly, although much of this goes unrecorded.

2.10 We see a far greater number of experienced corporate innovators in the UK than we did a decade ago. In our view this pool of people is every bit as much a resource which the UK should foster as is technological innovation. In consequence, we are currently looking at how to work more closely with such people in order to establish new businesses more effectively. These people fall, broadly, into two categories:

(a) "serial entrepreneurs"—people who have a track record of starting companies successfully. It is important that these people are encouraged to retain their capital in the UK for investment in subsequent ventures;

(b) entrepreneurially minded middle and senior managers in large corporations. Interestingly, we believe that one of the benefits of the growth in funding of management buy-outs by the UK venture capital industry is that a greater number of managers who would traditionally have remained within large organisations are becoming entrepreneurs. In our view, many of these people could equally become involved in younger, growing businesses and would have a lot to contribute, but they are deterred by the risks involved. In particular, we believe that they are influenced by the relatively high social stigma attaching to corporate failure in the UK compared with the USA and/or the financial risks involved. Working in large companies, these people are capable of earning high salaries and usually have a reasonable degree of job security. In moving to a start up company, they will typically have to forego both of these.

2.11 Increasingly, technology based companies operate in international markets, not just in the UK. Consequences of these trends are that it is harder to succeed long-term in many markets without a competitive edge that is global rather than local, and that ideas, entrepreneurs and capital are all increasingly mobile within the global economy.

2.12 Technology markets also develop quickly and speed in product development and establishing distribution networks has become extremely important. The sale of developed technology to foreign owned global companies is often, mistakenly, seen as a bad thing for Britain. In fact, it frequently represents the best way for the technology to be fully exploited and returns capital to the UK which can be re-invested in other projects.

3. *How successful have the DTI and other Government Departments been with their range of initiatives designed to stimulate innovation?*

3.1 A number of companies in which we invest have been recipients of SMART and SPUR awards. Whilst we have evidence of some research exploitation groups within universities regarding them as being of significant importance to the creation of new companies their focus is, by design, purely on promoting technical innovation. We feel that there could be merit in looking at schemes which might aid the career

[2] The recently launched European market aimed at emulating the success of the American NASDAQ exchange, which has been particularly successful in raising capital for technology businesses.

launch of more corporate innovators. It is this resource which we see as most limited in the UK and it might have a relatively large impact if it were specifically addressed, in addition to the existing focus on technical innovation, at which this country is, arguably, already comparatively strong.

3.2 A particularly relevant scheme for 3i is the Small Firms Loan Guarantee Scheme (LGS), in which 3i has participated since its inception. This scheme has been very successful in encouraging new business development as evidenced by a survey of successful 3i backed start-ups conducted in 1994 which showed that 38 per cent of them had received an LGS loan from 3i. The DTI restricts the maximum loan for companies which have been trading for less than two years to £100,000 (compared to £250,000 for "established" businesses) and the guarantee to 70 per cent (85 per cent for established businesses). When the scheme was last reviewed, we encouraged the DTI to consider raising the maximum loan for companies under two years to £250,000 and we would still support such a move. We believe that such a move could encourage 3i or a bank to make additional funding available at the crucial early stages of development.

4. How effective in terms of product or process innovation and other exploitable outcomes are initiatives which encourage collaboration between industry and academia?

4.1 We perceive the process by which academic research reaches the market to be along the following lines:

4.2 The two areas where we perceive the biggest difficulties arise are in raising seed funding and in marrying technology with an identified path to market with appropriate management capable of achieving the objective.

4.3 The amount of seed capital funding available in the UK has increased in recent years but it is still a scarce commodity. The difficulty arises largely in the level of management (and therefore cost) required for quite small amounts of initial investment. Whereas venture capitalists are used to working with cost ratios of, say, around 2 per cent of the assets under management, with seed corn funds this ratio can more often be of the order of 10 per cent. The number of initiatives to provide early state/seed capital is growing quite rapidly. 3i is invested in six funds which aim to finance the exploitation of university based research. Our experience with these is that exciting new opportunities can be identified but that it is difficult to generate a financial return overall which justifies the initial high costs and risks involved. We have also recently launched, in conjunction with Interregnum Venture Marketing, the "Step IT up" initiative aimed at providing marketing and management assistance for up to six months to new information technology businesses in the Thames Valley area. At the end of the six month period, successful projects are eligible to receive financial backing in the form of seed capital from 3i.

4.4 The second area is the successful marrying of entrepreneurial management with the technologists. We refer elsewhere in this paper to the issues which may deter corporate managers from moving to young technology companies. It is also the case that many technologists are suspicious of allowing external managers into their projects. In part this arises because of a lack of understanding betwen academia and the world of business.

4.5 The traditional view has been that industry and academia do not communicate with each other very effectively. This appears to be changing quite rapidly and has been encouraged by the universities' increasing needs to find finance from sources other than government. The relationship is most effective between the universities and larger companies, although in some places (such as Cambridge) increasingly sophisticated networks are developing between academics and the business community. We have heard the observation

made that the committees which run American univerisities tend to be biased towards business people whereas in the UK the bias is towards academics.

5. *Does financing need to be improved for technology-based small firms during their crucial start-up and early development phases?*

5.1 The early phases of a company's development are usually the most risky and financing needs to reflect this. The survey of successful 3i start-ups mentioned above identified that over 50 per cent under-performed in the first three years against management's original forecasts and that two thirds encountered some major crisis, most of which necessitated further rounds of funding. On average, 3i had made between two and three follow-up investments in these companies and remained invested for seven years before the business was floated or sold.

5.2 3i is capable of taking a very long term view of its investments. For example, we first invested in Oxford Instruments in the early 1960s when it was an embryonic business and remain shareholders today when it is a substantial quoted company. As another example, we made no fewer than six investments in Select Software between our first investment in 1990 and its flotation on NASDAQ last year. Clearly investors such as 3i, who have the resources to make subsequent rounds of funding, may be better suited for financing start-up companies than a closed fund with limited opportunity to make follow on investments.

5.3 The financial community is becoming increasingly familiar with the way in which technology businesses can grow in value even if they are loss-making for many years. The most obvious example of this is the growth in number of quoted biotechnology businesses, where the financial markets are prepared to take a very long term view of potential profitability. Whilst funding technology companies may need a long term perspective, the windows of opportunity for new technologies are typically short and if it is to have significant value it must rapidly be available throughout a global market. Young companies can rarely be expected to develop international distribution networks quickly, and larger multinationals already have these networks. The value in a technology based business is sometimes therefore only fully realisable through a trade sale to an international purchaser.

5.4 We need to recognise that the markets for technology companies are international. The UK's outlook should be similarly international if our native resource is to be fully exploited.

5.5 We should be concerned to retain our creative talent in the UK, both the technological innovators and the corporate innovators, and to make the UK an attractive place for talent from other countries to locate. We believe that it is important to develop what we see as a scarce and valuable resource and encourage this talent to be "re-cycled" into new ventures whenever possible.

6. *What other support systems could be introduced to ensure maximum advantage is taken of innovative ideas that originate with individuals or, for example, academia?*

6.1 Whilst we would not wish to be prescriptive about the nature of support systems we would identify possible areas for priority to be:

(a) encouragement for the development of more seed capital funds (perhaps by subsidising due diligence or monitoring costs, or underwriting some of the financial risk);

(b) encouraging corporate managers into young companies, perhaps through tax incentives, such as the ability to write off capital invested against past or future income tax liabilities;

(c) the encouragement of better communication between educational establishments and the world of commerce.

7. *Is there institutional inertia towards the funding of technology-based small companies? If so, to what extent may this be due to financiers' unfamiliarity with science and technology concepts and what should be done to address this?*

7.1 3i is one of a small, but significant, group of venture capital investors in the UK who take a very positive approach to technology investment. It is an area requiring above average investment skill because the markets for technology products and services are subject to rapid change and the companies themselves are therefore comparatively volatile. In particular, an ability to appreciate how value can accrue in a business during the development stages, ie before the business is making profits is important. Additionally, some broad appreciation of a range of technologies is important.

7.2 Whilst many investors in the area have a background in science up to degree level, or higher, typically they will need to look at proposals across a broad range of technologies. Inevitably the investor cannot be a technical expert across all areas and yet it can be critical to know enough to distinguish between the chances of success of competing new technologies. Successful investors have tended to adopt the same strategy for coping with this problem, that of using a network of people who can be accessed on any given subject. In 3i's case, we have a particularly valuable asset in our Industry Department, which contains advisers with specific technological backgrounds and a wealth of contacts.

7.3 Whilst in a broader sense, there may be a limited appetite for investment in technology businesses from institutions such as pension funds and insurance companies (because of the issues discussed above), our perception is that when sound technology and good quality management are successfully wedded together, obtaining funding is rarely a problem.

8. *The Committee recommended tax credits for research and development in our previous enquiry. Would this still be an effective way of fostering innovation and how should they be introduced to ensure that they are roughly cost neutral?*

8.1 Our main experience in the technology market is with young companies. Tax credits for R&D may well be an effective way of motivating larger groups, but younger companies are frequently loss-making for a considerable period, although value will be accumulated as the technology is developed. Tax credits against corporation tax are therefore unlikely to be a major incentive to these companies;

8.2 Rather than tax incentives at the corporate level we believe that there may be an argument to support tax incentives for:—

(a) private investors in technology businesses

(b) corporate innovators. Given that these people represent, in our view, the most scarce ingredient of the three required to successfully start a business, we think it could be beneficial to target incentives at:—

— serial entrepreneurs;

— managers (often in large corporations) who would be capable of starting new growth enterprises but are discouraged by the financial risks involved.

The Enterprise Investment Scheme ("EIS") may, in part, be aimed at this but, in our experience, its rules are complex and tend to be difficult to accommodate alongside more conventional institutional capital.

8.3 The financial rewards to individuals who invest in technology businesses usually come in the form of capital gains. Regardles of specific incentives, the rate of CGT is therefore likely to be quite influential in determining individuals' appetite to invest.

9. H*ow has the Technology Foresight Exercise influenced the availability of development funds for innovative ideas that were not given short term high priority status?*

9.1 We do not yet have any clear evidence of how this initiative has directly and specifically impacted on the flow of business proposals to us. A benefit of the initiative has been that it has encouraged greater dialogue between scientists and industrialists. However, we would question how easy it is to identify the way in which new technology may ultimately be applied in practice. An example would be X-ray crystallography, a physics based science which has ultimately played a crucial role in the development of the biotechnology industry. Yet twenty years ago, when it was being developed, it is unlikely that anyone would have foreseen this potential.

10. *Has tax relief introduced in 1992–3 for individuals' expenditure on vocational training had any impact on the status of continuing professional development, particularly for employees in small firms?*

10.1 We have no particular evidence to support or contest this view. Whilst welcoming measures which encourage the development of vocational skills across all businesses, we feel that it would not be wise to believe that most technical innovators can become excellent corporate managers through vocational training. In our experience, the combination of technological and entrepreneurial skills in a single individual is rare and it is usually necessary to bring people with the different skills together. In addition, the window of opportunity for much new technology is shorter than the usual training time for new entrepreneurs. Although we therefore sustain a belief that education and training are good things to encourage we do feel that it is often too late to do this once a specific opportunity is identified.

11. *Conclusions*

11.1 We believe that the UK is a rich source of technological innovation and that many new ideas are successfully brought to market by dynamic, independent companies. Whilst the number of institutions willing and able to invest in such businesses is limited, our experience is that funding is seldom a problem when both the technology and the management team are good. We welcome the developments of the AIM and EASDAQ markets which not only represent additional sources of capital but a potential exit route for early stage investors.

11.2 The most scarce resources would appear to be seed capital, to finance the development of the technology to the point at which the route to market has been identified, and good quality management to take the business forward from that stage. These are both areas where government may be able to provide some stimulus through the provision of subsidies and/or tax incentives.

11.3 3i has considerable experience of investing in technology businesses in the UK over many years, and we are pleased to have had the opportunity to contribute to this debate. We would be happy to answer any questions which the Sub-committee have on the contents of this paper.

APPENDIX

Some facts about 3i Group plc

Activities:

3i is the UK's leading specialist investor in unquoted companies and its aim is to become Europe's leading specialist investor in this field. 3i's investment activities include providing-start-up, early stage and growth capital, and providing capital for management buy-outs and management buy-ins. Around 900 of the businesses backed by 3i have gone on to acheive a stock market listing.

Company History:

The company was founded in 1945 as a "joint venture" between the Bank of England and the UK clearing banks. Since then 3i has invested more than £8 billion in over 12,000 businesses, and currently has investments in around 3,200 businesses in the UK and internationally.

In 1994, 3i Group plc was floated on the London Stock Exchange and subsequently entered the FTSE 100 index as one of the UK's top 100 quoted companies.

3i is an authorised institution under the Banking Act 1987 and is regulated in the conduct of investment business by SIB. 3i is a member of the Association of Investment Trust Companies.

Financial Information:

Fiscal Year End:	31 March 1996
Total Assets:	£4,100.8m
Shareholders Funds:	£2,528.8m
Net Assets:	£2,528.8m

Portfolio Analysis (31 March 1996):

By Industry Sector:	Mineral Extraction	2%
	General Industrials	45%
	Consumer Goods	13%
	Services	36%
	Financials	4%
By Location:	UK	90%
	France	5%
	Germany	3%
	Spain and Italy	1%
	Other International	1%

January 1997

Supplementary Memorandum by 3i

INDEPENDENT DIRECTORS PROGRAMME

Executive Summary

3i appoints independent non-executive directors to the boards of some of the companies in which it invests and believes that they can make a significant contribution to those businesses. New technology businesses are frequently likely to have management teams with limited commercial experience and the introduction of a non-executive director may be particularly relevant in these circumstances. The 3i Independent Directors Programme ("IDP") provides a register of potential candidates, who have been vetted by 3i, to fulfil this function. In our experience, successfully maintaining a register of this nature, requires a significant investment in identifying and assessing suitable individuals and in continuing to support them once they have joined the programme. Finding people of the appropriate calibre is not easy and it is particularly difficult to find people who have had experience of technology sectors.

1. *The role of independent non-executive directors*

1.1 3i's experience of investing in unquoted businesses over a period of more than 50 years has highlighted the benefits of introducing, in appropriate circumstances, independent non-executive directors to the boards of investee companies. Independent non-executive directors can bring a wealth of experience, which may be sector specific, or within a particular discipline such as financial management, or may simply stem from having experienced the trials and tribulations of running their own independent business. We see the support which an independent director can provide as being essentially different from that which is provided by an investing institution putting one of its own staff on the board. Their responsibilities are to the company and their role is to help management achieve or surpass their business plans, not to monitor 3i's investment.

2. *The particular relevance of independent directors to technology businesses*

2.1 Young technology businesses frequently face particular problems. They operate in markets which are subject to rapid change and they need to deliver challenging objectives in short time periods. They are involved in developing new products and new markets, frequently without an existing established business or organisational structure. In a typical early stage investment, the management team is likely to be strong on technical skills but may be weaker in terms of broader commercial experience.

2.2 A high calibre non-executive director, with relevant experience, can provide considerable support to the management of such businesses. It should be emphasised, however, that a good non-executive director is unlikely to compensate for seriously inadequate executive management.

2.3 It is often helpful if a non-executive director on the board of a technology company has had previous experience in a technology business. Our experience, however, is that such people are a relatively scarce commodity.

3. *History of 3i's Independent Directors Programme*

3.1 3i's Independent Directors Programme was set up in 1986 to provide a register of competent non-executive directors capable of supporting the management of some of 3i's investments. Potential candidates for the register are identified primarily via 3i's network of regional offices and are assessed both locally and by the London director of the IDP. Typically they will either have had direct experience of running their own companies or have worked at a senior level within a larger organisation.

3.2 A critical point in the development of the programme was the recognition of the need to match supply and demand closely and so, despite a high level of interest in the programme, a conscious decision was made to restrict the number of individuals on the register. This strategy has also helped to maintain the quality of the people on the programme. In 1996, the programme was involved in over 130 appointments and membership now stands at 400 individuals with over 600 appointments between them.

4. *Critical success points*

4.1 There are, in our experience, a number of key elements in the success of 3i's Independent Directors Programme. The selection of members for the programme is clearly a critical factor in determining the quality of the individuals on the register. Members will either be second time entrepreneurs, ie those who have already been involved in leading a successful start up, management buy-out or management buy-in, or they will have done something distinctive within a larger corporate, such as run an overseas division, established the group's main profit earner etc. Applicants are interviewed twice, referenced and credit and qualification checked. Members join for an 18 month probationary period.

4.2 It is also important to select the right person for any particular appointment. The management team and the 3i investment executive responsible for the investment will draw up a specification. 3i's IDP unit, management and their advisers are all then encouraged to suggest suitable candidates. Six suggestions are typically made by the IDP unit. Management then decide whom to interview and recommend to 3i as the chosen chairman or independent director. If their choice was not introduced by 3i then 3i will meet the candidate. We believe that this process ensures that management have confidence in the chosen candidate and do not feel that their non-executive director is an institutional imposition.

4.3 There also needs to be a sufficient flow of opportunities for members on the register to maintain their interest. 3i is particularly well placed, with a portfolio of over 3,000 companies, to be able to generate such a flow.

4.4 A further element of 3i's success is our commitment to the continuing development of independent directors' skills and research into best practice. Members of the programme are brought together through a series of quarterly regional seminars to encourage the dissemination of experience and best practice. Recent examples include case study events on Running Board Meetings, Managing Board Disharmony, Financial Risk and the Internet. We also conduct a survey of non-executive directors' remuneration.

Letter and Memorandum from Apax Partners & Co

Attached is Apax Partners' submission to the House of Lords Select Committee on Science and Technology, Sub Committee II enquiry into the Innovation-Exploitation Barrier.

To give you a brief description of our firm and, therefore, the relevance of our evidence, Apax Partners is an international independent firm providing private equity funding to entrepreneurial business. The group manages £1.5 billion of institutional funds and we are one of the few private enquiry firms in the UK that invests across the spectrum of early stage, expansion capital and management buy-out and buy-in opportunities.We have considerable experience of providing funding for early stage technology-based firms having invested in companies such as Scotia Pharmaceuticals, Chiroscience, Computacenter, Esprit Telecom, Filtronic Comtek and Cambridge Neurodynamics. Since Apax Partners raised its first fund in the UK in 1981, we have invested a total of £114 million in technology-based companies.

Apax Partners not only provides capital for the companies in which our funds invest, our team also comprises senior managers with specific industry experience who work on the Boards of these companies to help them achieve their objectives.

Dr Hamish Hale, one of our Healthcare Directors, and I would be pleased to provide oral evidence to the Committee. As you will see from my biography attached, I am a founder Director and past-Chairman of the BVCA and have been very involved with growth business in the UK both through the London Stock Exchange and most recently in setting up Easdaq, the new pan-European market for growth companies of which I am the Vice Chairman. Dr Hale, who has had a long and successful career in medical research and the pharmaceutical industry before becoming a very successful venture capitalist, has been a member of the panel on Healthcare and Life Sciences of the Technology Foresight Exercise since its formation. He was recently asked to chair the panel on Mentoring and Incubator creation for the DTI.

I enclose two general and three specific brochures about the Apax Partners which focus on some of our investments in the technology area and a recent report prepared for us by Dr Oonagh McDonald on the future impact of Continental European private pension funds on the private equity industry (*not printed*). I hope you find the attached submission informative and look forward to hearing from you about providing oral evidence.

Ronald Cohen Esq, Chairman

17 January 1997

Response by Apax Partners & Co

Apax Partners is pleased to submit its response to the Call for Evidence. Our response is based on our experience of investing private equity funds in early stage technology-based firms.

SUMMARY

Our experience as one of the few private equity firms in the UK that invests in early stage technology-based firms has shown us that there is a general disincentive to invest in these types of companies, particularly compared with the USA.

— Our research shows that, in 1994, 0.15 per cent of GDP in the US was invested in early stage ventures compared with 0.052 per cent in Europe. And, 0.22 per cent of GDP in Europe was invested in high technology ventures as opposed to 0.75 per cent in the USA.

The development of these companies is crucial, they are the large pharmaceutical, technology, electronics and computer firms of the future.

— Many of those companies that have had private equity backing are now multi million pound companies quoted on the London Stock Exchange. For example, there are currently 22 biotechnology companies listed on the LSE with a combined market capitalisation of £4.5 billion, all of which were venture backed.

We have been very involved in looking at ways of improving the availability of financing for these firms and believe that:

— a reduction in the level of capital gains tax for investors and employees in entrepreneurial companies, even in the short term, would significantly increase the amount of funding into these companies.

— the creation of sophisticated and highly regulated public equity markets such as Easdaq, the new pan-European market for growth companies with which we have been very involved, will stimulate investment in high tech companies by creating an exit route and increasing liquidity.

In response to the specific questions posed by the Committee, we submit the following:

1. *What is the current state of innovation in the UK?*

There is a considerable amount of exciting and innovative work being carried out in the UK but it is not necessarily being exploited to the full. The OST Foresight programme has recently reviewed the current state of innovation and, certainly for the Health and Life Sciences Panel, in the areas of scientific innovation, their ranking against worldwide competition has been defined. The results show that in many scientific areas the UK is a world leader in carrying out research and is second only to the USA in developing commercial opportunities from this research.

Apax Partners receives some 800 business plans to review every year, the majority of which indicate that there is a great deal of innovative work being carried out in the UK. As you will see from some of the enclosed information, we invest in highly innovative companies such as Cambridge Neurodynamics, the neural network company, and PPL Therapeutics, a company which produces animals, modified by genetic engineering methods, so that they secrete in their milk human therapeutic proteins.

2. *How successful have the DTI and other Government Departments been with their range of initiatives?*

It is difficult to measure how successful the DTI and other Government Department measures have been. The DTI was slow in realising what the commercial implications were for biotechnology and so initiatives such as the Foresight Programme are to be welcomed.

3. *How effective are initiatives to encourage collaboration between industry and academia?*

There has always been a strong collaboration between the pharmaceutical industry and academia but until now there has been little collaboration between start up companies and academia apart from a small number of new companies which were formed by academic entrepreneurs.

The new DTI initiative on mentoring and incubator financing is now addressing this problem effectively.

4. *Does financing need to be improved for technology-based small firms?*

Raising the seed capital to start a company is the most difficult phase in the financing of new technology. In the USA, the early finance often comes from high net worth individuals (often scientific serial entrepreneurs) and the large endowment funds (mainly from rich alumni) of the universities. Until recently, neither of these sources have existed in the UK which is probably a reflection of prior penal taxation policies which prevented the accumulation of wealth.

As has been highlighted by the Bank of England Report, there is a marked difference between Europe and the US in early stage investment by private equity firms. As can be seen from Charts 1 and 2, in 1994, 0.15 per cent of GDP was invested in early stage ventures in the US compared with 0.052 per cent in Europe and 0.22 per cent of GDP in high technology ventures as opposed to 0.75 per cent in the USA.

One of the ways of stimulating investment in young technology-based firms is the development of sophisticated public equity markets, particularly those which specialise in growth companies such as Nasdaq in the USA and the new pan-European market, Easdaq. Public markets provide liquidity for early stage investors and access to lower cost capital for successful companies. Many more early stage technology-based companies which have had venture capital backing float in the USA, mostly on Nasdaq, than in the UK. In 1995, 163 early stage venture backed companies floated in the USA compared to six in the UK. One of the reasons for this disparity is that it is much easier for companies which have not yet made a profit to float on Nasdaq than on London Stock Exchange. In 1995, no less than 39 per cent of the initial public offerings (new issues) on Nasdaq were companies that were not yet profitable at that time.

5. *What other support systems could be introduced?*

Our discussions with our investor indicates that, one of the most effective means of increasing the level of funding for technology-based small firms would be a reduction in the level of capital gains tax for investors in these companies. We believe that the current situation combining capital gains tax on assets such as property together with shares in entrepreneurial companies leads to a confusion of objectives. We would strongly advocate a differentiation, perhaps along the lines achieved for the Business Expansion Scheme, where an enterprise tax is introduced on the sale of shares in entrepreneurial companies to replace CGT and this rate of tax is 20 per cent.

6. *Is there institutional inertia towards the funding of technology-based small firms?*

Institutions do not invest in technology-based small firms because they consider the financial risks to be too great. Institutions do not have the technical capability to assess scientific aspects of businesses or the risk profile to invest in them. Their only method of investment is, therefore, through private equity funds.

As you will see from our attached report entitled "The Future of Continental European Pensions and their impact on the Equity Markets", we anticipate a considerable growth in the amounts that the UK and Continental European pensions funds together will have available for investment in growth companies. The pension funds should be encouraged to invest in small technology-based firms, either directly, through private equity funds, or through the stock markets to supply the necessary capital to enable them to meet their growing need for expendable finance.

7. *Would tax credits for research and development be an effective way of fostering innovation?*

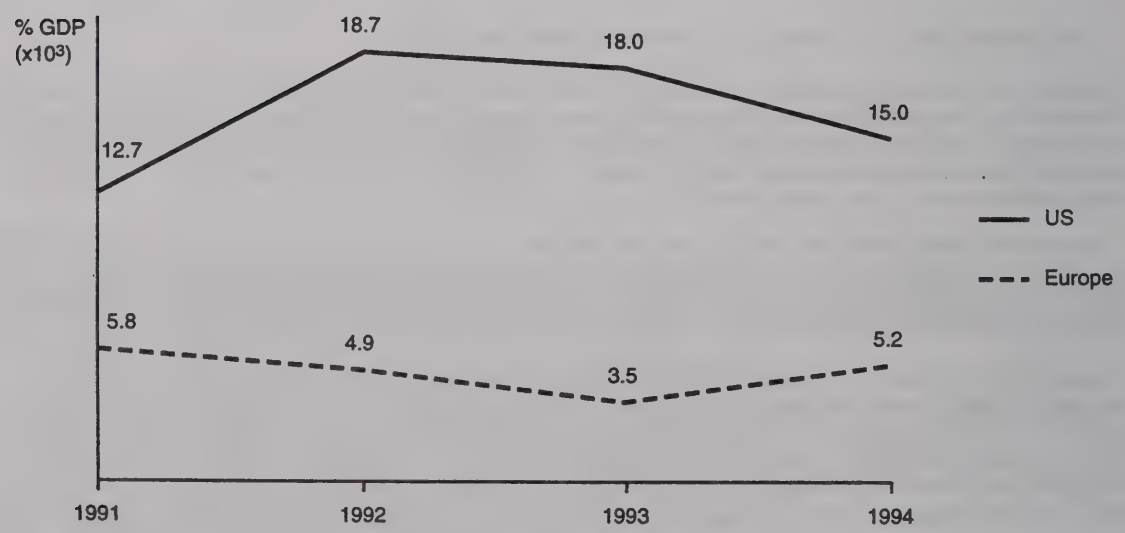
Tax credits are an excellent way of fostering innovation and may induce major companies to place development contracts with smaller ones.

8. *How has the Technology Foresight Exercise influenced the availability of developments funds for innovative ideas that were not given short-term high priority status?*

The Technology Foresight exercise has been an extremely complex exercise which has stimulated academia, industry and government departments to think about the economic implications of the commercial development of science. It has stimulated Research Councils to focus resources on certain sectors, influenced major pharmaceutical companies to support academia, influenced the DTI to create its Biotechnology Means Business initiative and raised academia's interest in starting new companies.

- There is a marked difference between Europe and the US in early stage investment[1].

% of GDP Invested in Early Stage Ventures

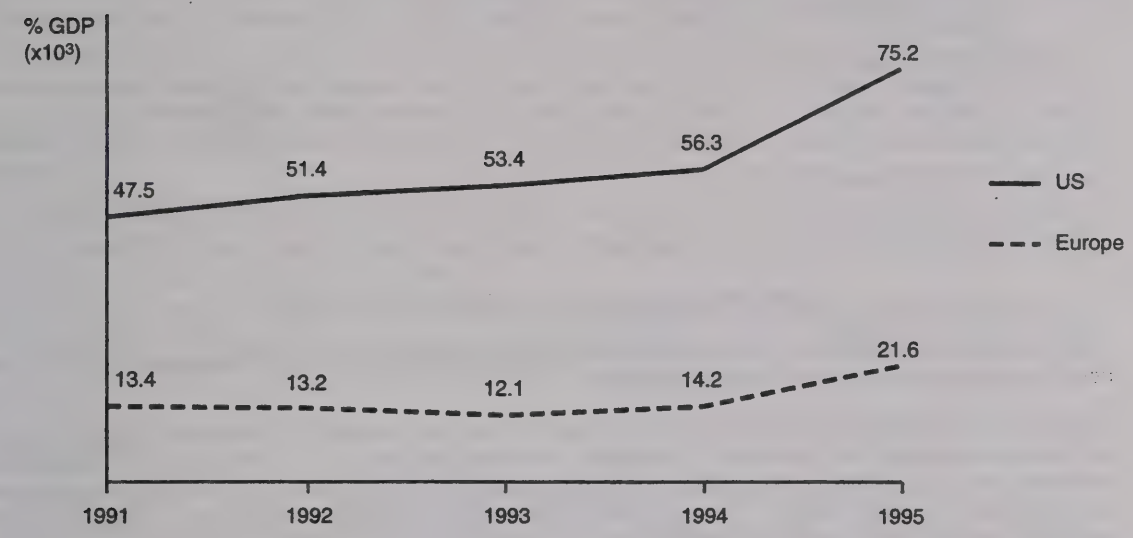


Sources: NVCA 1995 Annual Report, EVCA 1996 Yearbook, European Marketing Data and Statistics 1996, Apax Analysis
Note 1: Early stage investment defined as seed and first round financings

Less Early Stage Means Less High-Tech

- Early stage, technology companies require venture funding.
- The result: Europe invests less in high-tech than the US.

% of GDP Invested in High-Tech Ventures



Sources: NVCA 1995 Annual Report, EVCA 1996 Yearbook, European Marketing Data and Statistics 1996, Apax Analysis

UK BIOTECH COMPANIES LISTED ON LSE UNDER PHARMACEUTICALS

Biotech companies that have benefited from venture capital	*Market Cap £m*
British Biotech	1,347
Cantab Pharmaceuticals	103
Celltech	364
Chiroscience	283
Cortecs	238
ML Laboratories	295
Oxford Molecular	217
PPL Therapeutics	77
Peptide Therapeutics	78
Scotia	515
Therapeutic Antibodies	76
Vanguard Medica	128
	£3,721m

Source: BVCA, Financial Times

UK BIOTECH COMPANIES LISTED ON LSE UNDER HEALTHCARE

Biotech companies that have benefitted from venture capital	*Market Cap £m*
Anagen	14
Biocompatibles International	531
Biocure	5
Biotrace International	22
Celsis International	98
Drew Scientific	5
Enviromed (biotech)	6
Haemocell	1
Shield Diagnostics	27
Tepnel	23
	£732m

Source: BVCA, Financial Times

Letter from the Association of Electricity Producers

The Association of Electricity Producers has around 100 Members, and represents companies of all sizes, which use many types of fuel to produce electricity.

While the AEP does not have answers to your specific questions, it would like to stress the importance of innovation-exploitation to the electricity industry. About 60 per cent of our Members have interests in renewable energy. The development of new technologies and their successful introduction into the market are vital to this part of the industry. There are mechanisms that exist to promote renewable energy, but these could be improved. The Association has published two reports that outline experiences the industry has faced: *Renewable Energy: a policy review* and *Obstacles to the Growth of a Renewable Energy Industry in the UK.* These are enclosed (*not printed*). It will soon publish a document outlining suggestions for policy to encourage the further growth of the renewable energy industry.

I trust the documents are useful.

David Porter, Chief Executive

13 January 1997

Memorandum by Barclays Bank plc

INTRODUCTION

1. Barclays as a major Bank has always been committed to supporting business in the UK, and in particular those with growth potential.

2. We are aware of the value of innovation to the economy through the creation of new products and ideas, leading in turn to new manufacturing opportunities, and thereby to job and wealth creation.

3. As the creation of the new businesses provides Barclays with the opportunity to increase its stock of business customers, the success of innovative ideas being turned into exploitable products or processes in the UK is clearly an integral element of Barclays' own success.

4. Our interest in and support for this sector has been further demonstrated by Barclays involvement in the Bank of England report on "The Financing of Technology-Based Small Firms"—the recommendations of which have our support.

5. Though it is difficult to accurately define and measure this market we can give some indicative figures:

5.1 There are over 20,000 business customers of Barclays which can be described as potentially falling within this sector, by virtue of their classification within Computer, Electrical/Optical Manufacturing, and Telecommunications industries. These fall within all sizes, and include fast growth businesses, and as such all have differing needs.

5.2 Our support for the sector has been reciprocated by innovation-based firms choosing to bank with Barclays. For example c. 70 per cent of businesses based on the Cambridge Science Park are customers of ours.

BARCLAYS HAS A PARTICULAR INTEREST IN THE FOLLOWING QUESTIONS RAISED BY THE INQUIRY:

A: Does Financing Need to be Improved for Technology-based Small Firms During the Crucial Start-up and Early Development Phases?

Difficulties in Obtaining Finance

6. In terms of credit risk we do not believe that Innovation-based firms should be assessed any differently from other businesses. As a Bank we are seeking to ensure that propositions are not declined simply because they are not properly understood, but that the sometimes unique needs of such businesses are met.

7. However, although appropriate finance is a major requirement for Innovation-based firms, improving the management, marketing and financial skills of entrepreneurs is just as important. Therefore as part of Barclays' philosophy of adding value to our customer relationships, where appropriate we seek to provide the tools to improve their abilities in these areas, in part through introducing businesses to suitable support networks.

8. The financing of Research and Development based High Tech small firms is more difficult because:

8.1 Long development times for new products mean that finance through short-term facilities, such as overdrafts, are often not appropriate.

8.2 The complexity of the products being developed often makes the lending proposition difficult for the layman to assess, while their untested nature means there can be no guarantee of success, often making longer-term bank finance inappropriate.

Sources of Finance

9. Risk capital will usually be required which can be provided in one of the following forms:

9.1 Family-sourced finance which at the very early stages is often the only source of funds available.

9.2 Business Angel, along with Seed Capital, sourced finance would appear to be one of the most promising sources of finance for firms at this stage, although this field is still relatively undeveloped in the UK.

9.3 Venture capital, although the amounts required by new businesses often fall below the threshold required by venture capital firms to make propositions viable. For example Barclays Ventures minimum investment is £250,000, which makes it unsuitable for funding smaller propositions.

10. In addition there are Government and European backed finance schemes which can provide subsidised finance. Some, such as the Loan Guarantee Scheme (LGS), provide a guarantee to the lender where no alternative security is available.

10.1 Barclays is one of the largest providers of finance under the LGS, with 4,569 loans outstanding at September 1996, with total balances of £116m. A significant proportion of this was provided to assist firms in the development of new products and processes.

10.2 We would urge that consideration be given to extending the maximum capital-repayment holiday period for the LGS beyond two years to allow for the long lead times sometimes inevitable in innovation.

11. Barclays is a leading provider of the European Investment Bank Scheme (EIB) which can be used to reduce the cost of funding for borrowings over £30,000 with a minimum term of four years. The EIB can raise funds at very competitive rates, and we pass this benefit on to our customers. The primary purpose of this scheme, which can be linked to any of our loan products, is to assist in the purchase of fixed assets, which are often integral to the requirements of firms involved in innovation.

11.1 451 loans were disbursed by Barclays in 1996 with an EIB eligible value of £131 million where we were able to make payments of £461,000 to customers in the form of benefit.

12. The Barclays Employment Creation Loan Support Scheme, provided by the EU through the EIB, allows a rebate linked to each job created by small businesses equivalent to a cash payment of 10 per cent of the value of the loan (up to a maximum loan of £23,000 for each job created). Through this scheme cheap funding was made available to technology-based firms.

12.1 Unfortunately EU funds for this scheme are no longer available, but 179 loans were disbursed in 1996 totalling £58.5 million, with rebates totalling £3.9 million, equating to the creation of approximately 1,750 new jobs.

13. Barclays assisted the Department of Education and Employment in developing the Small Firms Training Loan (SFTL) which allows participating banks to provide subsidised funding by virtue of the Government guarantee. The SFTL is available for staff training, the hire of temporary staff cover, and a skill audit to establish real and practical training needs. Training requirements are often more pronounced in technology-based firms, and this scheme fulfils an important function in helping to meet these needs.

13.1 36 loans totalling £172k were disbursed during 1996.

14. Where appropriate working capital and/or longer term loans can be made available as part of a full package of banking services.

B: Is There Institutional Inertia Towards Technology-based Small Firms?

15. We are acutely aware of the danger of lending propositions being turned down simply because Lending Managers do not properly understand them. As such Barclays has undertaken a number of initiatives to provide our Managers with the necessary information to conduct informed assessments and provide relevant advice.

16. Barclays Business Policy papers have been issued to all relevant Lending Managers on the subjects of High Tech and Fast Growth Businesses, both of which are pertinent to this sector, High Tech firms often exhibiting rapid growth. These provide Managers with the necessary information to identify and analyse such businesses, both in terms of making lending decisions and providing relevant advice. They also articulate our supportive approach to these firms. In addition the Lending Adviser credit assessment system provides our Lending Managers with a unique and consistent knowledge-based risk assessment tool.

17. A complaint voiced frequently by customers, and one referred to in the Bank of England report, is that Managers change too frequently to develop a proper understanding of the businesses they look after. Barclays has now taken steps to ensure that its Lending Managers will remain in their positions for a minimum of 3 years, and if possible longer. A good Bank–Customer relationship is an important ingredient in the successful development of all businesses, and we believe that this measure should lead to a further improvement in the level of assistance provided by the Bank to Innovation-based firms.

18. There is a central unit, with expertise in this field, available to Managers to assist them should they require further support and to point them in the direction of relevant external organisations.

19. We provide information freely to customers in the form of Business Opportunities Profiles, covering a whole range of industries.

Other Issues

Support Networks via Outside Bodies

20. The Business Link network is a valuable source of information and advice in this field, as in many others, and we have developed close ties both on a national and local level, and are therefore in a position to provide our Innovation-based customers with an introduction to their technology councillors. We believe that by working together with bankers and entrepreneurs the technology councillors have a role to play in bridging the information gap, for example by assisting the entrepreneurs to put together effective business plans.

21. We also maintain links with specialist organisations and networks such as the Cambridge Phenomenon and The Welding Institute (TWI) and can introduce firms to these bodies where appropriate.

Conclusion

22. Barclays believes that Innovation/Technology based firms are vital to the economy of this country and to the success of Barclays as a commercial organisation.

23. Often conventional bank lending is not appropriate for such firms, and we believe that, through developing the profile of Business Angel and Seed Capital firms, additional funding sources will become available.

24. In particular, we believe that extending the capital-repayment holiday period for the Loan Guarantee Scheme beyond 2 years would be beneficial in broadening the appeal of this Scheme to assist in the development of innovative new ideas.

25. Barclays is acutely aware of the need to provide training to Managers so that they are in possession of the necessary tools to understand science and technology concepts. We believe this is a dynamic sector, and we are constantly looking for ways to improve our services to customers in this category.

26. We also recommend continued due co-operation between Banks, Business Links and other specialist organisations in order to continue developing this process.

Memorandum by Cambridge Research and Innovation Ltd

Introduction

Cambridge Research and Innovation Limited (CRIL) is a specialist seed capital investment fund. We invest in seed, start-up and early stage high technology based ventures. We now have almost 10 years experience of investing in this arena and as such feel we have perspectives which are likely to be highly pertinent to the enquiry being undertaken by this Committee. Attached to this submission is a Summary Profile of CRIL which explains what we do in more detail (*not printed*).

The responses to the Committee's questions are primarily restricted to our specialist knowledge of the high growth potential technology based companies.

1. *What is the current state of innovation in the United Kingdom?*

(a) Existing mature companies:

Our views are limited to general perceptions; industry is becoming increasingly aware that it needs to innovate to compete globally. Progress is patchy and market sector specific; IT and electronics industries suffered from its defence orientation and are behind the pack internationally, whereas pharmaceuticals and biotech are strong.

(b) The start-up sector:

Dramatic changes to the better have taken place over the last decade. Successful innovation has been driven by hard-nosed awareness of the potential for capital gain; the pool of seasoned entrepreneurs sensitive to using technology and new techniques to create commercial value (true innovation) is deepening.

2. *How successful have the DTI and other Government Departments been with their range of initiatives designed to stimulate innovation?*

In creating awareness of the benefits of innovation, our perspective is that they have been reasonably successful. Concrete benefits of the DTI "picking winners" through Smart and SPUR schemes are more doubtful. Visibility is generated for companies most innovative at massaging the DTI selection system, but correlation with ultimate company success (or any causal link with winning DTI awards) is not clear. Another, not verified, perception of CRIL is that the administrative cost of such schemes and lost time to all the "non-winners" probably outweighs the benefit. Creation of awareness is an important role, but has a limited life cycle.

A sector that has grown significantly through DTI support is the advisory sector; it is difficult to quantify the benefits and such support may be in danger of becoming a consultants "gravy train".

3. *How effective in terms of product or process innovation and other exploitable outcomes are initiatives which encourage collaboration between industry and academia?.*

These have undoubtedly made a worthwhile contribution because of the flow of benefits that arise; schemes could be geared better to smaller companies.

4. *Does Financing need to be improved for technology-based small firms during their crucial start-up and early development phases?*

We believe that there is scope for improvement in the support for funding at the earliest (seed) stage.

Start-ups need to access money that sets commercial challenges, provides incentives and comes with support that is committed, experienced and provides market intelligence. The challenge for a start-up which believes it has a technology of significance is to establish commercial structures and decision making processes that will efficiently create channels to markets and consequently value. Easily obtained funding does not necessarily place those challenging demands on small firms. Equity funding creates maximum potential for gain, but has built-in demand and motivations for value creation.

Of course, some of the most innovative (and potentially valuable) opportunities have a high risk of failure. Assuming that equity investment is an important ingredient and that highly innovative schemes are likely to be risky, the question that needs to be asked is whether business (management and investment) risk-taking in high potential high risk opportunities is sufficiently prevalent to capture optimum rewards for the economy. We believe that significant potential is being lost because on average risk-taking propensity is currently too low and the type of money (combined with support) that may compensate for these risks is not reasonably available. There is an opportunity for government to tip the scales by supporting those with the propensity to manage start-up risks and the preparedness to commit money and experience systematically. Financing for start-ups can be improved in at least two ways.

1. An equity guarantee scheme to modify the downside risks and bring the opportunity within the risk thresholds of a greater number with the experience and will to take business start-up risks (eg guaranteeing half the value of those prepared to risk equity on high potential start-ups).

2. A scheme of matching funding to be made available to those prepared to commit equity together with appropriate effort to high potential start-ups (funds like CRIL, which provide such a specialist combination, will be able to use this to significantly improve their fund raising capability amongst the pension funds and insurance companies).

5. *What other support system could be introduced to ensure that the maximum advantage is taken of innovative ideas that originate with individuals or, for example, in academia?*

An approach that promotes mentoring would add to the pool of experience devoted to building companies. CRIL has successfully invested capital by ensuring that its money is committed alongside experienced mentoring/counselling. In this context mentoring/counselling differs from consultancy in that the experienced individuals providing it are committed to the outcome of their "advice" by initially receiving little more than their basic costs in cash, but over time benefiting more substantially through options and shares. We strongly believe that consultants only have a role of providing short-term support under the control of the contracting company, but that real value accrues through maintaining commitment from experienced individuals who benefit from longer-term value creation.

Many of CRIL's start-ups were from academia and benefited from the mix of funding and equity-driven management input provided as a "cocktail" through CRIL. The CRIL internal structure and incentives are crucial to its own personnel and shareholders in ensuring that this process works. This is well beyond the scope of the submission, but may be relevant to further discussion.

It is worth making the point here that we believe the tax implications of shares and share options need to be simplified for early stage ventures to ensure that incentives to value creation, that already exist, are strengthened and not compromised nor complicated.

6. *Is there institutional inertia towards the funding of technology-based small companies? If so, to what extent may this be due to financiers' unfamiliarity with science and technology concepts and what should be done to address this?*

Yes—investment in early stage is a specialist effort and within the norms of venture capital management is hard to justify (eg a 2.5 per cent management fee is the norm accepted by fund managers and cannot sustain a special seed capital management company). The seed funds are consequently fragmented, generally small and "costly" to run. Because the amounts of money under consideration are small and performance statistics misleading, it falls outside the interest threshold of most fund management institutions. A government initiative to create a fund of funds targeted at seed only and created through a very small early stage support levy on institutions would be simple and cost effective, but controversial! We would be prepared to embellish these suggestions if requested.

7. *The Committee recommended tax credits for research and development in our previous enquiry. Would this still be an effective way of fostering innovation and how should they be introduced to ensure that they are roughly cost-neutral?*

This is big company oriented and we believe has little benefit; the problem is not the amount of technology available, but the risk propensity (in an entrepreneurial sense) of experienced individuals in creating value.

8. *How has the Technology Foresight Exercise influenced the availability of development funds for innovative ideas that were not given short-term high priority status?*

It has undoubtedly added some further vigour and process to big company prioritisation of strategic areas of interest.

9. *Has the tax relief introduced in 1992–93 for individuals' expenditure on vocational training had any impact on the status of continuing professional development, in particular for employees in small firms?*

Re-skilling and re-training is a priority for an effective workforce; this must have helped.

We believe that greater support for institutions which systematically provide specialist seed funding aligned with experienced support could further benefit the economy. This should not promote more "picking of winners" by government but marginally modify the risk environment at the earliest stages to encourage a greater number of those with experience and a propensity for managing risk to commit to a long (but rewarding) process of "building winners".

Memorandum by Cambridge University Local Industry Links ("CULIL")

CULIL has been set up to strengthen links between Cambridge University and local industry, with the aim of encouraging a strong technology-based industrial infrastructure in the Cambridge area. In September 1993 CULIL set up a Working Party to examine the funding problems facing small expanding technology-based businesses in the Cambridge region, of which there are around 700.

This submission is a summary of conclusions reached during meetings of the Working Party (see Appendix 1 for membership list). Several individual members of the Working Party have also made their own submissions to the Committee.

Finance for Small High Technology Businesses

1.1 Sources of Finance for Small High-Technology Businesses

The Working Party believes that for the vast majority of small-high-technology companies venture capital is not available at the level they require (ie £250,000 or less). We estimate that less than 20 investments per annum of this type are made in the whole of the UK. Business Angel finance or possibly Corporate Venturing finance appear to be the only practical way of filling this equity gap.

1.2 Business Angel Networks

Experience suggests that presentations at investors forums are an effective way of making introductions between companies and Business Angels, as personal chemistry between the company and the angels is important. In Cambridge, in contrast to other parts of the country, a forum has been set up without Government assistance by a local private sector fund manager. The organisers of this Forum accept that it does not directly pay its way, though at present they see sufficient spin-offs benefits to keep it running. However, the long-term existence of this forum may be in doubt because of its poor economics.

The Working Party strongly supports the work of this forum, and believes that it would be in the interests of the community to support forums such as this as part of Government financial support for SMEs. We believe that the ratio of new investment to subsidy would be very favourable. The same arguments probably apply to the other forums that are currently subsidised either by sponsors (eg LINC) or by the DTI.

1.3 Encouraging Business Angel Investment

Though forums are effective in making introductions, private investors and small companies have a great deal of difficulty in reaching an agreed deal.

The most common problems are:

— *management structure* (though an investor with skills to offer can usually get the company to adjust its structure to accommodate him)

— *deal structure* (may require outside advice, but size of deals does not make it economic to provide this)

— *valuation*, where there is usually a large discrepancy between the management's view of the company's worth and the investor's.

The latter problem can often only be resolved by an outsider providing an external perspective. Negotiations between companies and angels can often get bogged down in this area and drag on for a long time. The Working Party sees the length of time required to obtain new equity investment as a problem. At present there are almost no mechanisms available for dealing with it.

This appears to be an area where the market does not function effectively, and where a small amount of extra resources could make a large difference. These extra resources could come in the form of subsidised consultancy or possibly by small "catalytic" investments from a local fund. It is understood that the West Midlands Enterprise Board achieved some success by agreeing to subscribe for perhaps 5 per cent of the equity being sought, which then had a snowball effect in encouraging other investors. At this level the multiplier is 19:1, which is an effective use of funds.

1.4 Corporate Venturing

Some Cambridge companies have had success in attracting European corporate venturing investors, but experience with UK investors is poor. The latter show little interest and take a long time to reach any decisions.

The Working Party supports the suggestion of one of its members for an EIS-type scheme for companies. The proposal is that the cost of subscribing equity capital and of perhaps legal and other costs of entering in to the venture should be an allowable deduction in arriving at the venturer's taxable profits for the year. The investment would therefore only cost them 67 per cent of the money subscribed.

1.5 Financial Services Act

The Working Party believes that the uncertainty surrounding the FSA is having a damaging effect on the operation of Business Angels Networks and Forums. There is an urgent need for them to know what they can do within the Act. Most lawyers seem to give different advice. Clarification would give a considerable

boost to activity in this area. There is a similar, but less damaging problem over the uncertainty surrounding Shadow Directors.

1.6 Venture Capital Trusts

The Working Party believes that VCTs as presently constituted will have little or no effect on filling the gap in early stage finance for high-technology companies. However, if VCTs were permitted to purchase first round equity from Business Angels during a second round of funding, this would provide a useful exit route for angels' investments and therefore make it more attractive for the angels to invest in the first place.

1.7 Small Firms Loan Guarantee Scheme

The Working Party is strongly supportive of this scheme, and is keen to see it continued and developed further. There is evidence of unevenness in the way the scheme is applied between branches as well as between banks, and also major differences in interpretation between banks over whether marital homes of directors should always be included as "available security", a crucial factor. Some general guidance to the banks on how it is intended to operate would be useful in helping them apply it more evenly.

There would be benefits if the scheme was available as a long-term overdraft facility rather than as a lump sum loan, even with two drawdowns. In some cases companies have to re-invest their surplus borrowings; in others they are tempted to spend the surplus on non-essentials before it is finally needed. For loans over say £100,000 it may be economic for the Government to employ an outside agency, perhaps Business Link, to carry out a "Business Healthcheck", similar to the type used by NatWest, before the loan is made.

1.8 SMART and Other Awards

Again, we believe that these awards provide useful assistance to small firms, though the paperwork involved is excessive. Apart from that, the simplicity of the scheme is its main advantage. The SMEs do not have to obtain matching funds, which are often not available, and do not have to spend money (which they usually don't have) before they can reclaim. Most other SME initiatives suffer from the latter problems. It was agreed that SMEs find the present plethora of initiatives very confusing. We are aware of some sizeable schemes, for example £1.9m from the Regional Challenge Fund for grants to *under*-graduates to start up companies, *which we think are aimed at the wrong type of user, and could be better directed elsewhere.*

L K Fenelon
Chairman, CULIL Working Party on Small Business Finance

13 February 1997

APPENDIX 1

Membership of CULIL Small Business Finance Working Party, January 1997

Lawrence Fenelon (Chairman), Beauchamp Technology, Consultant working in SME Finance and Technology Transfer.

Robin Bligh, Touche Ross & Co., Partner with special responsibility for SMEs.

Chris Padfield (information only), University of Cambridge Programme for Industry, Chairman, CULIL Planning Committee.

Dr. Elizabeth Garnsey, Management Studies Group, C.U. Engineering Dept., Management Researcher.

David Brister, 3i plc, Investment Manager.

Walter Herriot, Park Director, St. John's Innovation Centre, Ex-Bank Manager and Incubator Director.

Peter Fielder, Barclays Business Centre, Bank Manager.

Christopher Saunders, Private Investor.

Chris Smart, Duncan Stewart, Lucy Block, Cambridge Research and Innovation, Venture Capital Managers.

Memorandum by the Confederation of British Industry

INTRODUCTION

1. This memorandum was prepared by drawing on experience from the CBI's Technology Group, SME Unit and Human Resources Directorate as appropriate. Whilst some consultation has occured with representative members, the short deadline means that a full consultation was not possible, although the paper provides a broad view of CBI policy.

2. The inquiry into *"the innovation-exploitation barrier"* comes at a time when a number of studies have highlighted the particular needs of small technology based firms (STBFs). These studies include: *Growing*

Success: helping companies to generate wealth and create jobs through business incubation[3], The Enterprise Panel; *The Financing of Technology-Based Firms,* The Bank of England[4]; and *Tech Stars: breaking the growth barriers in technology-based SMEs,* the Confederation of British Industry (to be published in January 1997).

3. The wider context of innovation has however been highlighted within the Country since the late 1980s. In 1989 the CBI initiated an annual *"Innovation Trends Survey"*, which has been carried out in conjunction with NatWest's Innovation & Growth Unit since 1990. The *CBI/NatWest Innovation Trends Survey*, as it is now known, has become a useful benchmark charting the perception of companies of all sizes in the UK towards innovation and the level of expenditure committed to support innovation. The survey was last carried out in March 1996 with the results being published in June. Next year's survey, the eighth, will also use the same timetable.

4. The evidence below is aligned with the questions highlighted in the call for evidence. However we have also appended copies of *Tech Stars: breaking the growth barriers in technology-based SMEs* and the 1996 *CBI/NatWest Innovation Trends Survey (not printed).*

Definitions

5. Whilst the CBI fully supports the Department of Trade & Industry's definition of innovation as *"the successful exploitation of new ideas"*, a more detailed definition is used for the *CBI/NatWest Innovation Trends Survey* as follows:

"Innovation occurs when a new or changed product is introduced to the market, or when a new or changed process is used in commercial production. The innovation process is the combination of activities—such as research, design, market investigation, tooling up and so on—which are necessary to develop and support an innovative product or process."

Responses to the inquiry questions

I. *What is the current state of innovation in the United Kingdom?*

6. In 1992 the CBI, working with the Department of Trade & Industry's Innovation Unit, carried out a study into nearly 100 companies to investigate the level of innovation in UK companies. The conclusions from the study were that:

— one in ten companies could be said to be truly innovative on a world-class scale;

— a further three in ten showed good performance in many areas;

— and another five in ten showed good performance in some aspects of the innovation process.

7. In 1992 therefore, although one in ten companies were truly innovative, many others had the potential to become world-class. The product of the interviews was a report—*Innovation: the best practice*[5] which led to further more detailed studies and a number of actions to promote innovation in UK companies. In particular the Innovation Unit and the CBI's National Manufacturing Council (NMC) have continued to work together.

8. Overall, the CBI believes that since 1992, there has been a significant shift in the perception of companies towards innovation. Exhibit 1 shows the expenditure reported by respondents to the *CBI/NatWest Innovation Trends Survey* between 1991 and 1995 for manufacturers and non-manufacturers. In both graphs there was a substantive increase in the level of expenditure in support of innovation between 1993 and 1994, although there was a slight drop in 1995.

9. The results from the *CBI/NatWest Innovation Trends Survey* provide a benchmark for companies against which they can assess their inputs and outputs from the innovation process. The R&D scoreboard also provides a benchmark. However care must be taken that investment in R&D is not taken explicitly to demonstrate best practice in innovation. Investment in R&D is only one input, albeit an essential one, to the whole innovation process. Without the other parts of the innovation jigsaw it is difficult for companies to successfully exploit new ideas.

10. The data presented in the *CBI/NatWest Innovation Trends Survey* is collected from a postal questionnaire and while it provides a very useful indicator of companies' perceptions and expenditure on innovations, it does not pretend to measure the level of best practice.

[3]1996 The Enterprise Panel, Securities Institute, Centurion House, 24 Monument Street, London EC3R 8AJ. Sponsored by Midland Bank.

[4]October 1996.

[5]1993 CBI/DTI.

EXHIBIT 1: Innovation expenditure

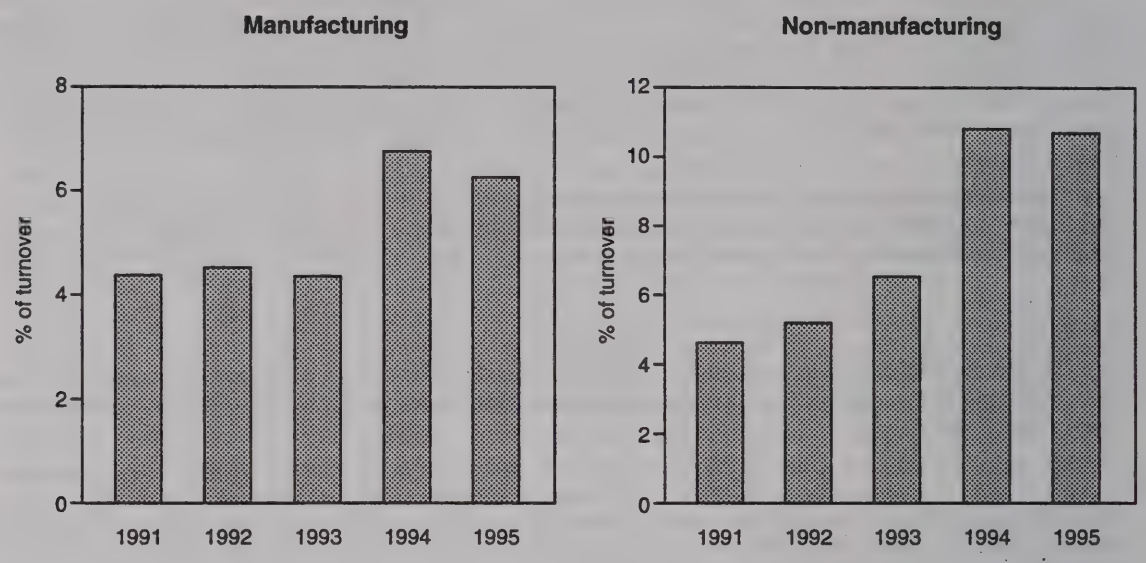
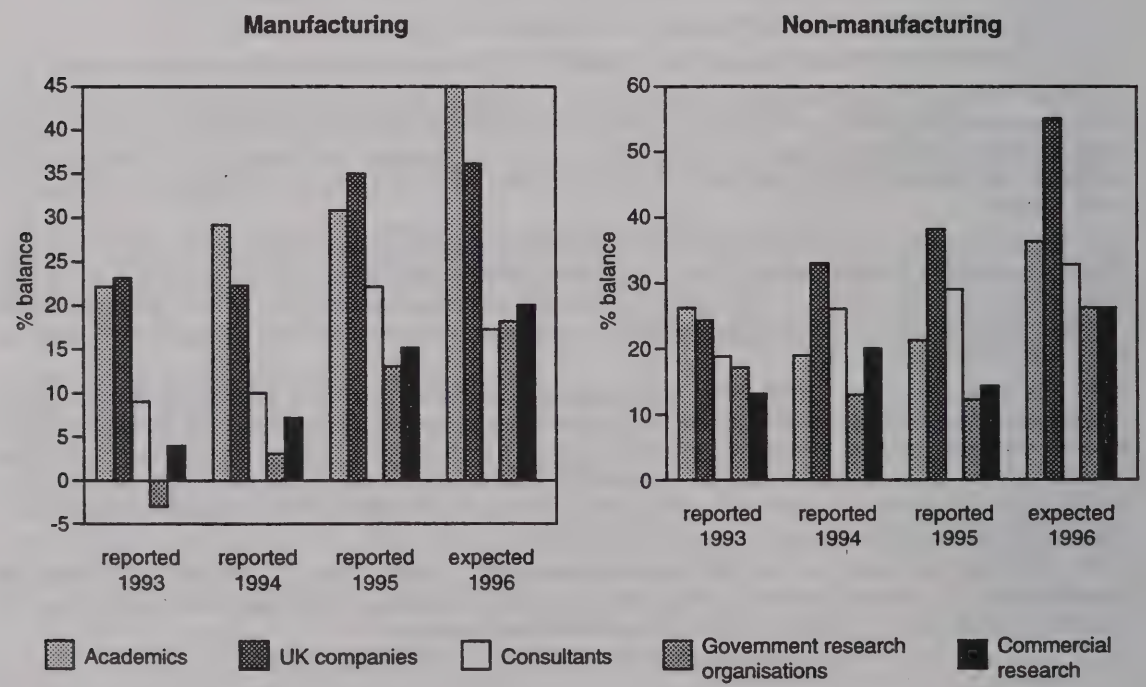


EXHIBIT 3: Collaboration

Q. What have been/are expected to be the trends in collaboration with ...



11. The Innovation Unit and the CBI are currently discussing how best to follow-up the original 1992 study and investigate what the state of innovation is in the UK after a sustained period of promoting best practice. The project is likely to go ahead in the latter half of 1997.

12. Until the follow-up study is undertaken, it is impossible to judge whether there have been significant improvements in best practice in innovation since 1992, although indications from the *CBI/NatWest Innovation Trends Survey* suggest that companies are lending it increasing importance and recognising that it impacts across the whole business process.

II. *How successful have the DTI and other Government departments been with their range of initiatives designed to stimulate innovation?*

13. Initiatives to promote innovation can be broken down into two broad categories—those designed to promote and benchmark best practice and those providing fiscal incentives to support some aspect of innovation. As highlighted above, there has been much effort focused on raising awareness on innovation from the Department of Trade & Industry and whilst investment figures collected from the *CBI/NatWest Innovation Trends Survey* suggest that companies are lending greater importance on innovation it is difficult to assess whether this translates into best practice. The comments made in response to question I apply.

14. There are a variety of responses by companies to the second type of initiative based on fiscal incentives. Exhibit 2 is a table listing the detailed figures from the 1996 *CBI/NatWest Innovation Trends Survey* on whether incentives at either the UK or EC level are adequate.

EXHIBIT 2: RESPONSES TO THE 1996 CBI/NATWEST INNOVATION TRENDS SURVEY QUESTION: "DO YOU FEEL THAT UK/EC GOVERNMENT INCENTIVES FOR INNOVATION ARE...":

	%Responding		
	...more than adequate	*...adequate*	*...less than adequate*
Manufacturers			
UK incentives	1	33	66
EC incentives	3	40	58
Non-Manufacturers			
UK incentives	2	30	68
EC incentives	4	32	64

15. However these figures should also be considered along with written comments made by respondents which can be broken down into four broad areas:

i. poor awareness of the fiscal incentives available (need for better promotion);

ii. confusion over the types and availability of assistance (highlighting the need for better promotion and access);

iii. too small a return on the investment in resources when applying for grants (ie success rate does not justify effort);

iv. and lack of tax incentives for innovation.

16. The first two points highlight a problem that many companies face in trying to identify appropriate assistance. The Business Links clearly have a role to play although their medium and long-term success will depend upon their real or perceived ability to identify appropriate assistance for companies.

17. Concern has been expressed by our members over the often large investment in resources, especially in terms of time, required to complete an application for a grant to support innovation. The Teaching Company Scheme is generally seen as an effective mechanism to reduce unnecessary waste of resources by providing advisers who assist companies with identifying appropriate projects and matching them with individuals. These advisers therefore act as a pre-filter for the application to the scheme.

18. The question of tax incentives is dealt with under question VII.

19. There is a substantial range of initiatives to support innovation within the DTI and other Government departments which could benefit by streamlining, creating fewer more flexible initiatives. There are two recent Government actions which should assist this. The first is the recent Government review of provision of business support[6] and second, the publication of an on-going strategy for Foresight[7] which will "...brigade a range of Government funded, technology-related, business support schemes which can be used to deliver Foresight...". Such simplification of Government support schemes should contribute in providing enhanced access to appropriate initiatives to support innovation building upon those which are most effective.

20. The SMART/SPUR schemes have, overall, good reputations. As highlighted in the recent Bank of England report on the financing of small technology-based firms, part of their value is in the recognition and

[6] "*Helping Business to win: consultation on a new approach to business support*", Office of Public Service, Cabinet Office, 1996.

[7] "*Winning through foresight: a strategy for taking the Foresight Programme to the Millennium*". Office of Science & Technology, DTI, 1996.

validation of an R&D project which can then assist with seeking further financial support. In other words a form of quality control. The DTI has been reviewing the SMART/SPUR schemes as part of the review of business and whilst there is a strong case for merging the two schemes into one under the SMART award banner, care must be taken to retain the regional and national approach which validates and maintains quality.

21. Whilst targeted funds can leverage investment in innovation, the regulatory and wider business climate can act as a constraint. There is a fine balance between regulations and standards which act as an incentive or facilitate innovation and those with an adverse impact on businesses. Consideration of the climate to encourage innovation within companies must therefore consider the wider business climate in which they operate.

III. *How effective in terms of product or process innovation or other exploitable outcomes are initiatives which encourage collaboration between industry and academia?*

22. The CBI believes that there continues to be a role for funding aimed at facilitating collaborative research between industry and academia. Such funding should be aimed at longer term R&D which is complimentary to all partners involved. The objective in research collaboration is to enhance the level of expertise to which you have access—for industry the universities provide a long-term strategic research base and collaboration with industry allows universities to access commercial research expertise and market applications.

23. It is difficult to draw a clear line between basic, strategic and applied research. This becomes increasingly difficult when comparing diverse sectors such as electronics, with time to market often counted in weeks or months, and pharmaceuticals, where development and certification of new products often takes many years. This necessitates varying the types of interaction which occur between university departments and companies in particular sectors.

24. Measuring the efficacy of Government initiatives to encourage collaboration, especially in terms of direct product or process innovation is difficult. Often companies themselves have difficulty in measuring the impact of their own internal investment in R&D.

25. Exhibit 3 summarises results from the 1996 *CBI/NatWest Innovation Trends Survey* illustrating the increasing level of collaboration between companies and academia, other companies and organisations to support innovation. For both manufacturers and non-manufacturers alike the increase in collaboration with academics is significant, suggesting that companies see universities as an important resource.

26. There are three main initiatives aimed at encouraging academic-industry collaboration each with a different objective: LINK, encouraging collaboration on specific research projects or themes; the Teaching Company Scheme (and related initiatives), placing young scientists and technologists into companies; and the Foresight Challenge. Each have their own strengths and weaknesses although they are generally viewed as a success.

IV. *Does financing need to be improved for technology-based small firms during their crucial start-up and early development phases?*

27. The recent Bank of England report provides a comprehensive picture of the financing of small technology based firms (STBFs). The CBI broadly concurs with its conclusions: that the nature of STBFs means that they require genuine risk capital at start up and early stage and that the UK venture capital and informal investor sectors seem to be less effective at providing such finance than its US counterpart. The CBI supports the broad recommendations of the Bank's report to address these concerns, such as developing the role of the venture capital industry—for example through establishing a clearing house for STBF finance proposals; encouraging the banks to consider their provision of working capital to STBFs; and examining the role of the US SBICs. In addition, the CBI's recommendations on the taxation environment for all SMEs will increase the flow of funds to STBFs, for example, through making the costs of raising equity finance eligible for tax relief.

28. However, the CBI's "Tech Stars" report on the barriers to growth in STBFs (previously mentioned and attached) (*not printed*), found that such firms faced many other barriers to growth than just access to finance. These are covered in the next section.

V. *What other support systems could be introduced to ensure that the maximum advantage is taken of innovative ideas that originate with individuals or, for example, in academia?*

29. The CBI's "Tech Stars" report on STBFs identified four major barriers to growth apart from finance which can be summarised as:

- building the right management team
- developing entrepreneurship and market focus
- exploiting corporate alliances

— protecting intellectual property rights (IPR)

30. Full details can be found in the report. Key recommendations include:

(a) Building management teams

— a Tech Star "clearing House" which would work with the best proposals that are turned down for finance and help to address their weaknesses

— database(s) of industrialists with management expertise in particular technological fields to help STBFs find non-executive directors, mentors etc

— promote "empty hive" approaches where local partners put together management teams and technological ideas are then inserted

— CBI and Government to review impact of recent changes in regulation of management share options schemes on STBFs, where they may hinder such firms' attempts to recruit top class managers

(b) Develop entrepreneurship and market focus

— Business Links/TECs to provide marketing advice/training to STBFs

— Universities to increase involvement in TCS/STEP

— Universities and local STBFs, to develop closer links, for example through incubator units or technology-business clubs

— EPSRC to encourage business management and marketing skills in science students, perhaps by enhancing such schemes as Graduate Schools Programme and Total Technology studentships

(c) Exploiting the potential of corporate alliances

— DTI/CBI to consider establishing a group to promote awareness of, and best practice in, corporate alliances.

(d) Protecting IPR

— a working group of interested parties to consider how the costs of protecting IPR could be reduced for STBFs.

31. Finally, the report argues that because of the national importance of promoting a vibrant Tech Star sector, the DTI should set up a Tech Star Unit to co-ordinate Government action in this area.

32. The recommendations from both the CBI and Bank of England reports should provide a sound basis for enhancing exploitation of new ideas through STBFs. More widely the recent consultation on delivery and simplification of business support by the Government should also help to rationalise and clarify the plethora of schemes available to support innovation.

VI. *Is there institutional inertia towards the funding of technology-based small companies? If so, to what extent may this be due to financiers' unfamiliarity with science and technology concepts and what should be done to address this?*

33. The Bank of England highlighted some gaps in the funding of STBFs notably the role of venture capital and the need for finance packages tailored for individual companies. A two-way "Empathy Gap" has been identified by NatWest's Innovation and Growth Unit, where both the financiers and the technology-based firms are found to lack the understanding of each others' needs and objectives. For example, the Bank of England report found evidence to suggest that financiers' lack of understanding of technology is a problem for technology-based firms. On the other hand, there is evidence to suggest that "Tech Stars" do not have the expertise or skills to prepare and present a coherent business strategy, which is an absolute necessity in securing finance. This problem should be solved by the recommendations in the CBI report in enhancing management skills in 'Tech Stars' and on the introduction of more informed lenders and technology investors.

VII. *The Committee recommended tax credits for R&D in our previous enquiry. Would this still be an effective way of fostering innovation and how should they be introduced to ensure that they are roughly cost-neutral?*

34. Members of the CBI present a mixed view on whether there needs to be a change in the tax environment to encourage investment in R&D. The current situation, where R&D investment can be written off against corporation tax in the year of expenditure, does provide some incentive but this does not assist start-up companies who may not be in profit for a number of years. The CBI therefore feels that consideration should be given to the particular position of STBFs, especially start-up firms, as highlighted in the CBI 'Tech Stars' report.

35. The case for extending tax incentives to promote innovation is not clear. Whilst there have been a number of studies regarding the benefit of tax incentives to R&D investment, it must not be forgotten that R&D is only one, albeit important, input to the process of innovation. It is difficult to see how tax incentives for innovation *per se* could be developed which were not overly complex and increased the burden of bureaucracy on companies.

36. The question of tax incentives must also be viewed against the background of international competition. Many other countries have more significant incentives for R&D and therefore the case for extending incentives in the UK is enhanced. However comparisons between countries must be treated carefully as some commentators have noted that definitions and interpretation of R&D expenditure can vary.

37. Consideration should be given to using the Foresight programme as a means to encourage innovation in companies. The recent Foresight strategy document, previously mentioned, is a positive step which highlights the sector Panels who will be developing their own strategies over the next few months.

38. One effective mechanism for measuring the impact of Foresight on the business community in the medium term may be to monitor the investment in R&D on a sector basis. This is now feasible with the track record of the DTI's R&D scoreboard. The Panels could also set small targets for improvement in R&D investment for sectors of particular importance in relation to Foresight priorities.

VIII. *How has the Technology Foresight exercise influenced the availability of development funds for innovative ideas that were not given short-term high priority status?*

39. The object of Foresight was to identify priorities by looking at technological and market opportunities with a 10 to 20 year horizon. These priorities are being used to inform public expenditure on science, engineering and technology. The priorities identified and the scenarios built during the Foresight consultation can be also be useful for companies.

40. The Foresight programme itself should not drive the university research base short-term, but bring together academics and industrialists to work towards long-term strategic targets. It was not designed to stop basic research but rather place it in the context of wider national priorities. Clearly it is impossible for the UK to sustain leading edge research in all areas of science, engineering and technology—the Foresight programme is a mechanism to inform decision making about where research funding should be focused.

41. It is too early a stage in the alignment of Government support for research and innovation to judge whether any innovative ideas—especially those in line with Foresight priorities—were not able to access appropriate funding.

IX. *Has the tax relief introduced in 1992–93 for individuals' expenditure on vocational training had any impact on the status of continuing professional development, in particular for employees in small firms?*

42. Identifying the effect of tax relief for individuals' expenditure on vocational training on the status of continuing professional development (CPD) is difficult. The increase in CPD over the last few years may be attributed to a number of factors. For example, many professional organisations such as the Chartered Institute of Accountants, or the Institute of Personnel and Development have made it compulsory for their members to undertake CPD if they wish to maintain their professional status.

43. Neither the DfEE nor the Inland Revenue have any concrete information of help on this issue, although the prevailing view is that it is unlikely that the tax changes will have had any significant impact on CPD. The tax relief changes in 1992–93 only applied to individuals working towards NVQs—the range of NVQs available to professionals is limited. It was announced in the 1996 budget that tax relief for individuals is to be extended, but only to those in full-time education. Again, therefore, this is unlikely to affect the status of CPD.

Letter from the Confederation of British Industry

During our recent telephone conversation, you asked me to provide some more detailed comment on the results of the Innovation Trends Survey carried out in conjunction with NatWest. In particular you asked about the significant leap in expenditure reported by respondents between 1993 and 1994.

During analysis of the data for the 1994 figures the CBI carefuly analysed the population responding to the survey. We felt that this was likely to have the greatest significant effect on the reported expenditure. However, the number of companies responding for both manufacturers and non-manufacturers was similar and the distribution of turnover and number of employees did not vary significantly.

We believe that the increase in the proportion of expenditure committed to innovation reported in 1994 was a reflection of companies' evolving interpretation of innovation. In particular the thrust of the work by the DTI's Innovation Unit and the CBI itself has focused on a holistic approach to innovation. That is not only looking at inputs such as R&D, but also market research, training and design for example. In addition innovation also raises questions about the organisation of a company. Consequently the reported expenditure on innovation by UK companies is likely to include at least some component of these wider business activities. If companies are looking at the wider implications of innovation within their business then the work in promoting innovation can be seen, at a minimum, as a partial success.

The *CBI/NatWest Innovation Trends Survey* is a very useful indicator of companies' perceptions on innovation. However the caveat is that it cannot hope to identify whether a particular company can be considered to be following best practice. This is why the CBI and DTI Innovation Unit are currently

considering a follow-up study to that carried out in 1992 which led to the publication of the *Innovation: the best practice* report.

Dr Philip Wright, Technology Group

27 January 1997

Letter from the Construction Industry Council

I am writing to thank you for inviting contributions towards the House of Lords' Science and Technology Committee's inquiry into Innovation-Exploitation Barriers.

As you may know, the Construction Industry Council (CIC) is the representative forum for all the professional bodies in the construction industry, collectively representing over 350,000 individual professionals and over 10,000 consulting firms. It was formed in 1988 and its principal objectives are to promote improved value for clients and to encourage unity in the construction industry to emphasise its significance in the nation. A full list of members is attached *(not printed)*.

I understand that the Construction Research and Innovation Strategy Panel (CRISP) has written to you about this inquiry. CIC is a constituent of CRISP and wishes to support the submission of the draft consultation document *"Creating a Climate of Innovation in Construction"*.

There are three other matters which may be helpful to the inquiry. The first of these is the CIC publication *"Profit from Innovation: a management booklet for the construction industry"*. The key message of this publication is that consultants and contractors of all sizes can profit from the management of innovation, at little additional cost. The challenge of profiting from innovation lies in harnessing ideas and technology efficiently and routinely for competitive advantage. A copy of the publication is enclosed *(not printed)*.

Secondly, I enclose a copy of a working paper prepared to examine related issues entitled *"Private Funding for Construction Innovation and Research: Options for a National Initiative" (not printed)*. A key message of the working paper is that those who benefit should pay is hard to apply for research and technology transfer of general benefit.

As such, a concerted national effort is required so that all beneficiaries of increased research and dissemination contribute equitably to its achievement.

Thirdly, CIC has recently been awarded a contract through the Department of the Environment's "Partners in Technology" programme examining innovation within the construction industry. The primary objective of this project is to address the *motivation* aspect of the Whole Industry Research Strategy of the construction industry in order that the maximum impact for improvement can be achieved. This is drawn from the latent energy to innovate that undoubtedly exists within the construction industry.

The project builds strongly from the CIC/DoE *"New Way of Working"* conference held in January 1996 at which participants from all sides of industry discussed and debated the alternatives to achieve new ways of working within construction through innovation. The conference achieved two things; it created a network of stakeholders involved in construction centred on the CIC, upon which this project will draw, and it put innovation in a much broader perspective.

Main thrusts emerging from an analysis of the conference taken up in this project are:

- Motivation will not be forthcoming if innovation is seen as an end in itself, but seen as a means for companies to use selectively to achieve their own objectives it has great appeal.
- Innovation needs to be applied to "baseline industry methods" and especially the integration needed between many small players.
- The important role of materials and components manufacturers and suppliers needs to be acknowledged. These players must be included in any analysis.

I hope that you find this contribution of assistance in the Committee's inquiry and trust you will not hesitate to contact me in case of any question or query.

Graham Watts, Chief Executive

22 January 1997

Letter from the Construction Research and Innovation Strategy Panel

I am responding on behalf of the Construction Research and Innovation Strategy Panel (CRISP), to the invitation to submit evidence on the issue of the "innovation-exploitation barrier".

CRISP is a body initiated by the construction industry, its clients, and Government with the objective of identifying and promoting the key research and innovation issues facing the construction industry and its clients. The membership of CRISP is drawn from the main construction industry and client representative bodies, and has established a number of sub-Groups to take forward its work. I enclose a copy of the CRISP brochure which explains CRISP's objectives and priorities in more detail. Key amongst CRISP's early

priorities was the identification of research and innovation (R&I) issues associated with the "creation of a climate of innovation" in construction. This work is being taken forward by the CRISP Motivation Group, chaired by Dr Peter Bransby, Director General of CIRIA.

The Group's work directly relates to the main issues being considered by the sub-committee, and so we would like to submit the attached draft consultation document "Creating a Climate of Innovation in Construction" which summarised CRISP's views (*not printed*). We would be happy to expand the views given in this document should an opportunity be made available to us. The Group is also developing a more detailed strategy document outlining its thinking, which I will forward to you in due course.

I hope you find this contribution helpful.

Richard John, Head of the CRISP Secretariat

20 December 1996

Memorandum by Context Electronic Publishers

1. The current state of innovation in the UK is not good.

2. I have no direct evidence recently of the value of the initiatives of the DTI except a negative one a few years ago.

3. Collaboration between academia and industry is potentially a good option. Academia has ideas and solutions to problems but no ability to produce and market reliable products for the market place. There is unfortunately a lack of understanding between the two sectors.

4. Finance is crucial especially in the start up and early years of a new company. Unfortunately the Banks are unsuitable in this process since they lack technical knowledge and are impatient for a financial return. Most innovations need three to seven years before becoming operationally profitable.

5. Creative individuals in academia need support staff in order to implement their ideas but this support is hard to finance in the university environment.

6. Financial institutions such as Banks have no understanding of technology. There is a need for technical expertise at the highest levels. The technical dimension is now as important as production, sales, marketing and accounts.

7. Tax credits assume a company is profitable enough to pay tax. This may be true for large corporations but not for small startup companies. Creative use of VAT may be better.

8. I have no experience of the Technology Foresight Exercise but, like motherhood, it is a good thing.

9. Tax relief for training is only just being noticed. I hope some of my staff will be able to take advantage this year.

I would support the above answers by my experience in setting up Context Ltd which is relevant to your committee's agenda. I am a qualified physicist who has worked in the Admiralty, the Atomic Energy Authority, the European Commission, the International Thomson Organisation and I am now a Director of Context Ltd. I will stick to the story of Context though much of my earlier experience is relevant.

Context is an Electronic Publishing Company which specialises in legal databases published online and on CD-ROMs. I was asked to start it up in 1985 when the EUROLEX project was closed down. The objective was to set up a legal database service which used the MEMEX hardware retrieval system developed in Scotland under the auspices of the Scottish Development Agency. In effect Context would provide a shop window for MEMEX as well as being a company in its own right. The finance came from venture capital provided by Stewart and Ivory Merchant Bankers in Edinburgh. In the first three years the company was technically successful and proved the value of the MEMEX device. However sales of the online service grew too slowly, though the database of EC law did well, and at the end of three years Context went through a complex double takeover process (to protect the equity of the bank) and Context ended up in its present holding group Scandex Ltd and its subsidiary Capscan Ltd. This was by agreement. Context is a private company with one owner who is a qualified engineer who has considerable technical knowledge as well as the necessary financial resources.

The first decision made after the takeover was to put some of the Context databases on to CD-ROM. Capscan had CD-ROM know-how but no data while Context had data but no CD-ROM expertise. The combination worked well from the start and Context has built on that success. At the end of 1988 Context employed three people and had a turnover of approximately £40,000. At the end of 1996 Context employed 37 people with a turnover of £3.2 million and is a truly profitable company.

The reasons for success include technical strength in depth plus knowledge of the specialist legal market together with a financial regime which recognised that several years were required for new technology to beome acceptable in the market place. Context really began to move forward in 1991–92 some seven years from its starting date.

The main lessons are that technical innovations require:

(a) financial support for a timescale of five to seven years

(b) technical knowledge and understanding at the board level.

Finally I would add that I did the original research on which Context is based in the late 1960s and early 1970s so it has taken about 30 years for this technology to take root in the commercial life in this country.

Norman Nunn-Price
Database Director

13 January 1997

Letter from the Economic and Social Research Council

Professor John Goodman has forwarded a copy of your letter to him dated 24 January 1997, concerning the Economic and Social Research Council's Innovation Training Materials Initiative.

The ESRC Innovation Training Materials were developed in response to the 1993 White Paper, *Realising our Potential—A Strategy for Science, Engineering and Technology,* which directed the ESRC to fund the development of modules for the teaching of innovation on masters' degree courses and continuing education programmes in UK Business Schools.

Six sets of materials were developed in response by key academics at leading business schools in the UK. Each contributed to a different aspect of innovation management:

Module 1	Product Innovation	Professor John Bessant University of Brighton
Module 2	Process Innovation	Professor John Bessant University of Brighton
Module 3	Technology and Strategy	Professor Rod Coombs UMIST
Module 4	Creative Problem Solving	Dr Tudor Rickards University of Manchester
Module 5	Implementing Technological Innovation	Dr Harry Scarbrough and Dr Jacky Swan University of Warwick
Module 6	The ESRC Directory of Innovation Courses	Dr Paul Gardiner Open University

The six sets of materials should prove very useful in the teaching of innovation. They have been designed to be customised for use in the curriculum by those teaching in the innovation management area.

The ESRC Postgraduate Training Division has already encouraged active dissemination of the materials in the business schools. Activities have included: a conference for 110 business school delegates at Warwick in July 1995, the publication of a directory of postgraduate innovation courses to promote networking both within and between universities of those involved in teaching the management of innovation, piloting of the packages in twelve business schools and the production of a publicity brochure (*not printed*).

The launch of the materials in Spring 1996 also included dissemination seminars in 45 business schools. The remaining business schools have been mailed packs of all the materials with disks. The six packages are also available on the World Wide Web signposted from the ESRC Postgraduate Training Division's homepage at http://www.esrc.ac.uk/postgrad.html.

At the launch Ian Taylor, Parliamentary Under Secretary for Science and Technology, welcomed the initiative stating that "the ESRC had made a major contribution to moving the innovation agenda forward". He expressed the view that the training materials would be widely used to help UK companies to "strengthen their innovative potential and become more competitive in world markets".

Since the launch of the materials an Innovation Training Knowledge Exchange Group (KEG) has also been established as an active network which provides a forum for those teaching innovation management to share their experiences and teaching materials. Membership of the KEG originally consisted of faculty who helped develop the materials. It is now expanding and is open to all those involved and interested in innovation management training. Its first newsletter was mailed to all business schools in October 1996 (*not printed*). It is hoped that the group will help to promote networking in this growing community and facilitate the transfer of new research findings to course organisers.

The appropriateness of the Innovation Training Materials, their utilisation and their impact on the curriculum of UK business schools is currently being assessed by an evaluation team led by Professor Peter Swann. Professor Swann presented an interim report to the ESRC in October 1996 which indicated the initiative has been a considerable success and good value for money. The materials produced were thought to be of high quality and a number of business school academics have indicated they will find them a valuable contribution to their courses. Professor Swann will be submitting a final evaluation report to the ESRC in March 1997.

I hope this will be helpful to the Committee. Should you require any further information or a set of the materials themselves please do not hesitate to contact me.

Phil Sooben
Director of Postgraduate Training

3 February 1997

Memorandum by the Engineering Employers' Federation

INTRODUCTION

The EEF has over 5,200 member companies of all sizes, from all major sectors of the UK engineering industry. It is the largest single-industry employers organisation in the UK and seeks to influence Government thinking in areas relevant to the Engineering Manufacturing industry, including the development of innovation and best practice.

In the submission, we are pleased to respond briefly to some of the issues outlined in the call for written evidence.

EXECUTIVE SUMMARY

The EEF in this written submission has addressed Questions 2, 3, 5, 6, 7, 8 and 9. The EEF is not in a position to give a substantive submission on Questions 1 and 4.

Historically the UK was considered, and arguably still is, the fountain head of creativity in scientific, medical and technological development.

Core to wealth creation in the UK is the Engineering/manufacturing sector, particularly those companies that are innovative in the development of new products and strive continuously to improve existing products.

- Engineering is a particularly complex industry with many of its end products being components of further larger products. Within the finance institutions, there is a general view that they are not in a position to assess whether a product is a good one or even how large the market is. Ignorance breeds fear!
- Innovation, the successful exploitation of new ideas, is vital if Engineering companies are to compete successfully in the global economy and create jobs and prosper in the process. To innovate requires continuous investment.
- It is essential that Government Departments are more pro-active and less bureaucratic in its support of manufacturing/engineering companies in the crucial stages of product development.
- The Financial sector should be more forward looking and strategic in its thinking and understanding of the Engineering/manufacturing sector. There appears to be a particular problem for SMEs and start-up companies in obtaining funding for innovation and development of new products.
- There is a need to look at investment in vehicles other than Venture Capital Trusts to provide fiscal incentives for companies developing products. This might take the form of Partnerships whereby individual investors are encouraged by fiscal measures to invest in innovation and product development with SMEs.

Question 2. *How successful have the Department of Trade and Industry (DTI) and other Government Departments been with their range of initiatives designed to stimulate innovation?*

The level of success of DTI and other Government Department Initiatives is very difficult to quantify. SMEs (and this applies as well to companies with turn-over in excess of £10 million), within the Engineering/manufacturing sector developing new products or existing products tend to view Government initiatives on innovation as not really available to them. The initiatives appear to be designed more for the large organisations with established R&D departments who are able to devote resource to applications for Government funding which by nature is very bureaucratic. For SMEs it would be encouraging if a more pro-active marketing approach is directed at them, by Government Departments. It would also be helpful if the DTI could to some extent embrace the role of mentor towards SMEs.

The December 1996 review of the inter-relationships between the Science, Engineering and Technology Expenditure of Government Departments made a number of recommendations which, if implemented, would go some way in achieving a more pro-active role.

The modest efforts of the DTI to date have met with some success, but we doubt that the present scale of activity has sufficient critical mass to bring about significant change. The meeting of academics and industrialists in a common cause was novel. For many academics the process was regarded as yet another hurdle for securing research grants and it is perhaps naive to suppose that a gentle nudge of grant spending patterns would achieve revolution overnight. Industry's enthusiasm for the process waned considerably once

those stimulated into innovative programmes realised that the early stages were the least expensive, leading to more resource intensive parts of the process involving innovation, production, marketing and selling.

Question 3. *How effective in terms of product or process innovation and other exploitable outcomes are initiatives which encourage collaboration between industry and academia?*

The DTI has a key part to play in the spread of best practice and in the understanding of business processes. The recommendations contained in the Innovative Manufacturing Report "A New Way of Working" are as relevant today as they were in 1994 when the report was published.

It is certain that short term initiatives are ineffective and judgement of the effectiveness of Foresight programme would be premature. There is a substantial culture gap to be closed which will take time unless drastic action is taken.

Academics in general must learn that the creation of scientific and technical knowledge in the absence of market pull is a very poor use of this country's scarce university funding and that touting such "products" to industry is bound to be frustrating and ineffectual process. The exemplification of the one or two successes over the past ten years only misleads the majority of academics who have never worked in industry, and continues to delude Government officials into ways to justify academic research. For its part industry must recognise that innovation is not a haphazard process and certainly must not be left to the "boffins" to create scientific and technical push: it requires planning by and courage from the very best of brains in all those disciplines that contribute to the conduct of business.

The EEF believes that a sharper focus could be brought to the relationship between university and business if certain universities were designated as specialists in applied research and encouraged to develop stronger direct links with local business, leaving other institutions to concentrate on "blue sky" or strategic research.

Question 5. *What other support systems could be introduced to ensure that the maximum advantage is taken of innovative ideas that originate with individuals or, for example, in academia?*

The EEF views the following developments as desirable:

- Assistance with the setting up of Commercial Development Working Plans for SME's at the very early stage of development.
- Mentoring from organisations such as Innovation Clubs and Research Associations to improve the quality of innovative management within the engineering/manufacturing industry.
- Easier access to patent and intellectual property protection. It may be considered necessary to give financial support as well as resource to ensure innovative products are quickly protected.
- Centralised high quality support for SME's such as
  - (1) mentoring style assistance through government departments, TECS, Business Links with effective collaborative delivery through the encouragement of science and technology parks
  - (2) Cluster approach
  - (3) Patent application support
  - (4) Inclusion of innovation management in Business Studies/MBA courses
  - (5) Advice in licensing and intellectual property transfer.
- Specific programmes to create links between SME's and academics, perhaps through local "innovation clubs" and through secondment/work experience for students.

Question 6. *Is there institutional inertia towards the funding of technology-based small companies? If so, to what extent may this be due to financiers' unfamiliarity with science and technology concepts and what should be done to address this?*

Finance Institutions are reluctant to support SME's in the development of innovative product development or in improving existing products during the first stages of development.

Small companies and start up companies in the first stages of development of products are generally funded by overdrafts, often secured against personal assets. There is a particular problem for SME's because of risk aversion by High Street Banks. The amounts may cover the initial stages of the product development but may not be sufficient to take the product to market. Institutions tend not to support development unless there are proven sales or accounts showing successful market penetration. Once there is sufficient evidence to show market profitability, Institutional finance tends to be available.

In order to address this problem, the EEF, in association with Lloyds Bank Commercial Services has developed a training programme to train managers from the bank to understand the technical and financial environment of engineering sector SME's. Other clearing banks are now being offered the same programme.

Many SME's cannot afford to self-finance the product through development to market. At this stage either they are bought out by larger concerns or the product assigned or licensed to other companies and developed as their own.

Mentoring SME's in technology transfer techniques may assist this process. Lenders generally like to see good project/product planning, for example, using the step method in developing products. UK manufacturers tend to wait until a product is at its final development before going to market. In competitive countries products are developed over a five year cycle, with the Mark 1 in the market within the first stage (say six months) Mark 2 is produced and brought to market as the next step, and so on until the product has reached its final stage of development (say after five years). At each step the product has achieved market penetration. Finance Institutions are more inclined to lend support at each stage of this cycle of development and having a shorter time to market at each stage reduces the perceived risk to lender.

Question 7. *The Committee recommended tax credits for research and development in our previous enquiry. Would this still be an effective way of fostering innovation and how should they be introduced to ensure that they are roughly cost-neutral?*

The EEF has not been able to solicit the view of it's members on this question. However there is a view that a favourable tax regime would be a stimulant for innovation and product development.

Question 8. *How has the Technology Foresight Exercise influenced the availability of development funds for innovative ideas that were not given short-term high priority status?*

There is insufficient evidence from our membership that Technology Foresight has yet influenced the availability of development funds.

Question 9. *Has the tax relief introduced in 1992–93 for individuals' expenditure on vocational training had any impact on the status of continuing professionals development, in particular for employees in small firms?*

Training is an essential part of all business but in the engineering industry it is especially important that skills are updated to keep pace with technical developments and enhance competitiveness.

It is felt that it is too soon to judge the effect of this tax relief. The scheme has been given very little publicity and there is little evidence of significant uptake in the engineering sector.

Memorandum by the Engineers' and Managers' Association

Executive Summary

In the view of the Engineers' and Managers' Association (EMA), the main impediment to exploitation of innovation in British industry is the short term view of investment taken by the financial institutions. This leads to British companies failing to invest adequately in new products and processes. The particular case of the reduction in Research and Development spending by the Electricity Supply Industry since Privatisation is cited in some detail, as an illustrative example.

The view is expressed that there needs to be a fundamental shift in attitude of the financial establishment in the United Kingdom towards a more "European" model, if this situation is to be corrected, in the long term. As a shorter-term palliative measure, it is suggested that a generously-funded Research Foundation financed by a levy on industrial companies be set up. The object of this body would be to fund innovation and exploitation over larger time scales than currently contemplated by British companies.

The Engineers' and Managers' Association (EMA) is a trades union representing Professional, Technical and Scientific Staff in a range of industries, primarily in Electricity Generation and Supply, but also with appreciable numbers in Shipbuilding and Aerospace.

In preparing our subsmission we have drawn heavily on the experience and expertise of our members, in particular those at EA Technology Limited. This Company is actively engaged in the development and application of energy-related processes and technologies with a high degree of innovation, throughout United Kingdom industry. Our members in this Company are actively involved in the development and exploitation of new technologies as researcher and middle-manager, and have everyday "hands-on" experience of the problem of overcoming the barriers to innovation in United Kingdom industry.

A corporate view from the management of EA Technology Limited is, we believe, to be the subject of another submission to yourselves. Our submission can be taken as a more direct input from the staff themselves, at the level where the innovation-exploitation barrier actually exists.

In our opinion the need for innovation, and indeed the necessity of maintaining a technological base in the Economy of the United Kingdom, are becoming increasingly ignored or at least under-valued by the financial and business establishments of the nation.

We do not support the view that a modern European economy can be built solely on the basis of a service economy, if it is to maintain or improve the standard of living of the country. A wide and flourishing industrial base is essential for the United Kingdom.

It is clear that such a base cannot be built, or maintained on the back of the United Kingdom's traditional industries. Once new technological developments are taken up progressively by the "developing" countries of the world, they will be able to compete with and, due in large part to their inherently lower labour costs, undercut comparable British industries.

Unless the living conditions in the United Kingdom are permitted to fall to those of a third world country, we can only compete by bringing a continuing stream of new and innovative industrial products to the world market. It is clear to the EMA that the process of innovation is absolutely vital to the future progress of the country. However, as mentioned above, this view does not appear to us to be shared by the financial "establishment" of the United Kingdom, in particular.

To illustrate the above thesis we will draw upon our extensive experience of representing Scientists and Technologists responsible for research and development in the Electricity Supply Industry throughout the United Kingdom, although our remarks will regrettably be seen to apply equally to virtually the whole of British Industry, with a few honourable exceptions.

From its last major restructuring at the start of the 1960's, up to the time of privatisation, the electricity supply industry built up a considerable Research and Development effort which was highly regarded both throughout the United Kingdom and abroad, and had a continuing record of success in introducing technological innovation both directly in its own business of electricity generation and supply and throughout British industry.

In 1990 the electricity supply industry operated four major research and development facilities, three covering the industry's own interests in the field of electricity generation and transmission, and one covering electricity distribution and the utilisation of electricity in homes, offices and industry. Of these four laboratories only two have survived the privatisation process, the successor Power Generation and Transmission companies having closed the former Central Electricity Generating Board (CEGB) engineering laboratories at Marchwood in Hampshire, and reduced the central laboratory at Leatherhead in Surrey to a small facility covering only high voltage transmission development for National Grid plc. Much smaller development facilities have been set up by both National Power and PowerGen but the total staff employed in those three centres is now only some 150-200, compared to well over 1,000 in the former CEGB laboratories.

The Berkeley Nuclear Laboratory of the former CEGB (in Gloucestershire) has survived in somewhat better shape, but the nature of the work carried out there has changed to that of little more than a support facility for the decommissioning of Britain's ageing Magnox Nuclear Power Stations, and there have also been considerable manpower reductions. Thus, since privatisation, the generating side of the electricity industry has opted out totally from any innovative research and development. The rationale is apparently to rely on any innovation to be introduced by the electrical plant and equipment manufacturers. However, these are increasingly based outside the United Kingdom and without any United Kingdom-based Research and Development underpinning these companies it is difficult to envisage a profitable long-term future for heavy electrical plant manufacture in Britain. In effect, the United Kingdom is opting out of yet another area of relatively high-technology industry, to the benefit of our overseas competitors.

In this context we should mention the case of the fluidised-bed coal combustion development orginated by the CEGB and the National Coal Board, which has now passed into Swedish hands.

The remaining laboratory for the electricity industry at Capenhurst in Cheshire is now owned and largely financed by a consortium of regional electricity companies, with a minority interest held by National Power. Funding of this centre by the electricity companies has been steadily reduced since privatisation, however, and the establishment is now little over half its size at privatisation.

In every case, the driving force behind the massive reductions in research and development capability in the electricity supply industry has been the desire of the companies to maximise their profits. Research and Development is apparently seen as a "loss", although in the longer term it is, of course, not only profitable but vital to the growth, or even survival, of any technologically based companies.

Of equal concern, the nature of the work carried out by EA Technology, the current operators of the Capenhurst laboratories, is now largely short-term development aimed at getting processes and equipment into the market in extremely shore timescales—often under a year. This precludes involvement in any true innovative work. Again, this is driven by the desire of British industry for a very rapid return on any investment in Research and Development—typically British companies will expect to recover all their development costs in less than 18 months.

We believe the above scenario is replicated throughout British industry. The essentially short-term view taken by all financial establishments in the United Kingdom is stifling the entire innovative process, to the extent that UK companies spend far less, by any measure, on Research and Development than their competitors in other developed countries.

Against this background, the various initiatives of the Department of Trade and Industry (DTI) and other government departments to stimulate innovation, and the collaboration between companies such as EA Technology and the universities, can only be palliative measures.

Clearly, if as we suppose, one of the main obstacles to innovation in the United Kingdom is the high (and rapid) rate of return expected on investment in Research and Development, then a system of Tax Credits and other financial incentives to British companies to invest in innovation—indeed even to regard innovation as an investment—would be highly desirable. We believe that grants are a relatively unwiedly and slow method of getting funding when it is needed. Whether such incentives can ever be sufficient to overcome the onerous financial requirements of the funding institutions in Britain, without infringing European legislation governing fair competition, is open to question.

We believe that a fundamental shift in the view financiers have of the returns they expect from investment in innovation is required. This is not so much institutional inertia, or an unfamiliarity with scientific or technological concepts, as based on a totally unreal set of expectations. Investment in new technology is seen to be high risk—which it is. The climate both financial and cultural in terms of risk-taking needs to be addressed, and Government seems to have had little or no impact here.

In short, the financiers of British industry need to be educated out of their short-termism. This in itself is likely to be a slow process.

As described above, our experience of the effect of privatisation on innovation in the electricity supply industry has been almost wholly negative. If private companies driven purely by the profit motive continue to fail to fund the innovative process—and we believe they will, in the short to medium term—then another mechanism to fund Research and Development in the civil sector must be found. Furthermore, the mechanism must provide secure funding over a period of several years for fundamental, highly innovative developments.

The cost of transferring technology to the market are always underestimated. An old rule of thumb is:

1 unit of expenditure : Research

10 units of expenditure : Development

100 units of expenditure: Transfer of successful product to market.

Even if the proportions are not usually quite so great, it remains true that good research requires the backing of sufficient and greater funds for development and implementation, if its results are to be successfully exploited.

A project champion is required within a company to ensure successful exploitation. The climate of fear in terms of job security if the project/product fails means that people are increasingly reluctant to be identified as the champions of new and risky projects.

A mechanism for secure, long-term funding might be afforded by the establishment of a Research Foundation which would be a major grant-awarding body. Funding on a continuing basis could be provided by means of a levy on industrial companies, offset against the value of any Research and Development carried out by the companies on their own behalf.

We consider that there may also be advantage in promoting a more fundamental shift in institutional arrangements towards those prevalent in the rest of the European Union. For example, the close links which exist at board-management level between banks and medium-to-large companies in Germany fosters a much higher degree of stability and continuity in the financial support of companies than is prevalent in the United Kingdom.

Similarly, the relatively low percentage of companies which are quoted on the Stock Exchanges in, for example, Italy, France and Germany, leads to less emphasis on short term dividend yields as a measure of company performance than is current in the UK; and companies can devote more of their effort towards the long term view which is necessary to support innovation.

We believe that it should be possible within the different structure of British corporate finance to encourage closer links between companies and the financial institutions and a better informed and longer-term approach to the future returns from research, innovation and new projects. We do not accept the view that a shift towards a more "European" approach to corporate finance and the rates of return would restrict the provision or availability of so-called "venture" capital in the UK.

We believe that there is undue focus on small and medium-sized enterprises in Government thinking. While much innovation does derive from smaller companies, we believe that the Government underestimates the role of larger firms, which are better able to spread their risks, in the development and exploitation of new technologies.

In our opinion more brochures, seminars, initatives etc. from Government departments have little or no discernible effect. It is financial assistance which reduces the risk associated with the initial investment which is required, but it must be delivered more speedily and effectively than it is at present.

CONCLUSION AND SUMMARY

We believe that the underlying cause of the United Kingdom's failure to exploit innovation is the short termism of British Industry. To correct this, a change in culture is needed, to one based on a more "European" model. Government will need to take a lead in this, but will have to involve both management and employee organisations (the "Social Partners", to use the European term) from an early stage, as well as the financial "establishment".

Introducing such a change is clearly going to be a relatively slow process. In the interim, we suggest a range of measures—such as fiscal incentives through the taxation system, and a well-funded grant-aiding body, to encourage the exploitation of innovation by British companies of all sizes.

Terry Moulding, Research Officer

13 January 1997

Memorandum by the Engineering and Physical Sciences Research Council

Introduction

The Engineering and Physical Sciences Research Council supports a number of activities aimed at advancing knowledge and technology which can meet the needs of users and beneficiaries, thereby contributing to the economic competitiveness of the UK and the quality of life. The following paragraphs describe the main steps which the EPSRC has taken to encourage collaboration between academia and industry and to promote successful exploitation of academic research generally.

The EPSRC's research programme is divided into a set of eight programme areas. Three of these are based on core scientific disciplines (Chemistry, Physics and Mathematics) and two are technology based (Information Technology and Materials). The engineering area has recently been reorganised into three programmes; General Engineering, Engineering for Manufacturing and Engineering for Infrastructure and the Environment. The Innovative Manufacturing Initiative which is described below, is an important collaborative activity within the Engineering for Manufacturing programme, specifically addressing the link between innovation and exploitation.

Schemes for supporting innovation

Much of the EPSRC's support for collaborative research involving industry and academia is channelled through the responsive mode, where the choice of the research topic and the engagement of industrial partners originate with the proposer. In addition, we have also taken steps to encourage collaboration, by increasing the breadth and range of initiatives designed to stimulate academic/industrial co-operation and innovation; the Faraday partnerships provide a recent example where we expect to see increased and measurable exploitation of research results, alongside building strong and effective networks between academia and industry, in particular with the SME sector. Postgraduate Training Partnerships, Engineering Doctorates, Research Masters and the Teaching Company Scheme all involve partnerships between industry and academia. Emphasis is always placed on the extent to which the research work of these collaborations is exploited.

Encouraging exploitation

We have recently commissioned exploitation "audit" pilots with four universities. The overall aim is to achieve a better understanding of exploitation processes, and how the EPSRC, working together with the universities, can contribute to strengthening current practices. The pilots will examine all aspects of the exploitation and technology transfer process, including the use of the different support mechanisms available and the movement of people between universities and industry. The linkages between research disciplines or technologies and individual industrial sectors and between research disciplines across the science base are also being explored.

The Innovative Manufacturing Initiative

The Innovative Manufacturing Initiative aims to support high quality strategic and applied research, and related postgraduate training, in response to the need for a "business process" approach to manufacturing within UK industry. An important feature of the IMI is its sector-based approach to colloborative research partnerships. Consortia typically consist of groups of companies and groups of universities able to share information and ideas. These consortia enable the outputs of the research to be taken forward and exploited both within the project team and to a broader constituency within the industrial sector concerned. Cash and in-kind contributions from industrial partners ensure that such outputs are "proved" in an industrial environment. The effectiveness of this approach is beginning to emerge as the first research results appear.

The initiative, which was launched in 1993, also involves the ESRC and BBSRC, with financial support from the DTI and DoE.

Memorandum by the Enterprise Panel

This is a submission by the Enterprise Panel to the Select Committee as part of its enquiry into the Innovation-Exploitation Barrier and how innovative ideas from the UK's science and technology base are turned into exploitable products or processes.

Summary

The Enterprise Panel, an independent body set up by HM Treasury and financed by Midland Bank, believe that the wider use of business incubation practices should be encouraged in order to ensure that the maximum advantage is taken of innovative ideas that originate with individuals or in academia and improve the prospects of the successful commercialisation of research.

— Business incubation is a process which can deliver stronger businesses, create jobs and produce firms developing new ideas and technology. It provides firms with intensive hands-on support to combat the most common reasons for failure or their inability to reach full potential viz: lack of breadth of business skills and lack of finance. Business Incubators selects firms best able to benefit from support, combat the loneliness and stress of setting up a business and its early development, give access to a range of business skills and training to help the business grow, provide access to finance and enable new enterprises to stand on their own feet more quickly.

— Success of business incubation. While more analysis is still needed on the impact of incubators, experience in the USA, where there are over 900 incubators, as well as in the UK and rest of the Europe is that incubation provides a method or system for overcoming some of the key problems in the growth of new and small companies commercialising innovative research or ideas. In particular improving links between financiers and companies seeking support, improving financiers familiarity with innovative companies' needs and technological ideas and developing the business skills of new ventures.

— There is a lot happening in the UK. There are already a small number of established incubators in the UK and many more projects are currently being developed. The Panel identified 30 new projects in its report. But much more needs to be done to promote business incubation benefits and best practices so as to fully realise the potential of this form of support system offers for technology transfer and the commercialisation of research and new ideas.

— "Corporate Venturing" is another form of business incubation where large companies help the foundation and development of small innovative companies in a number of different ways. Whilst this is being undertaken by some pharmaceutical companies in the UK there is still considerable scope for its promotion and development.

— The Panel are trying to establish a Business Incubator Centre to act as a catalyst to promote and encourage busines incubation in the UK, generate best practice and networking between incubators, help new projects develop and promote the status and training of incubator directors.

The Enterprise Panel

The Enterprise Panel was set up by the Treasury in May 1995, with Midland Bank as sponsors, to identify whether there were greater benefits to be gained in the UK from business incubation principles as practised in the USA and elsewhere, with the objective of reducing the failure rate of start-up businesses and increasing the success rate of the small percentage of companies that achieve real growth, particularly in terms of technology transfer and the commercialisation of research and new ideas.

The Panel's report, "Growing Success", was launched by Angela Knight the Economic Secretary to the Treasury, in July 1996. It emphasised the important role incubators can play in growing new businesses and the benefits of involving the private sector. Its principal recommendation is to establish a Business Incubator Centre which will promote in the UK the benefits of business incubators, particularly for the private sector, increase the networking of incubators and help new ones develop. The report has been widely welcomed, most recently by the Bank of England in its report "The Financing of Technology-Based Small Firms". The Panel are remaining in existence for a further year, again sponsored by Midland Bank, to put in hand the implementation of its recommendations.

Why is business incubation important?

Business incubation is a process or "tool" which can deliver stronger new businesses, create jobs and produce firms developing new ideas and technology, a market failure for which Britain is often criticised. Incubators using business incubation can help develop the fast track companies that are the real creators of

future wealth and employment. In the USA since 1979 over 75 per cent of new jobs have been created by less than 10 per cent of small businesses.

Although business incubation is relatively new and is still evolving, there are some 900 incubators in the USA. The most prominent incubators are those which have generated substantial local economic growth and/or development of new technologies, eg Austin Technology Incubator, Kansas City Centre for Business Innovation, Massachusetts Biotechnology Research Institute. While much more work still needs to be done in analysing the impact of incubators it seems clear from experience in the USA, as well as in the UK and the rest of Europe, that incubation provides a method or system for overcoming some of the key problems in the growth of new and small companies commercialising innovative research or ideas from universities, large companies, etc. This includes improving links between financiers and companies seeking support, improving financiers familiarity with innovative companies' needs and technological ideas and developing the business skills of new ventures. Ultimately incubation helps businesses survive, an EU survey of its Business Innovation Centres (a form of incubator) found that survival rates for new businesses in a BIC were 85 per cent compared with 50 per cent for small businesses generally.

What is business incubation?

Business incubation is a process which helps small firms counter the reasons for most failure or inability to reach full potential viz: lack of breadth of business skills and lack of finance. Small firms are provided with hands on support, business skills and access to an environment aimed at building success. *Business incubators* select firms best able to benefit from support, combat the loneliness and stress of setting up a business and its early development, give access to a range of business skills and training to help the business grow, provide access to finance and enable new enterprises to stand on their own feet more quickly.

The four distinctive features of incubators are:

— Some form of selection or entry qualification to judge business's viability and growth potential, eg a formal business plan;

— The incubator director has a close "hands-on" relationship with client businesses;

— Businesses are encouraged to leave or graduate within 2-3 years by which time they should have reached sufficient maturity;

— Their performance is judged not only by the number of client businesses, but more importantly by the success of those businesses in growing.

Important factors for a successful incubator

There are no model solutions to establishing an incubator. What works in one place or sector will not necessarily work well elsewhere. Business incubation can be applied in quite different situations for different objectives. For example in the USA there are high tech incubators, ethnic incubators, virtual incubators etc. However incubators are arguably most effective when applied to supporting innovative businesses, particularly those with substantial growth potential. The key factors, important in making such incubators successful, are:

— links with organisations, eg universities and/or large companies, which are interested in commercialising their own or others research by supporting small innovative companies and in providing such ventures with access to their technical expertise;

— links with venture capital companies both from local angel networks and venture funds interested in providing equity finance for fast track companies;

— links with local business support providers, eg banks, Business Links, Training and Enterprise Councils;

— access to knowledge of best practices, which will help incubators develop their range of services, address specific problems or establish innovative new projects;

— strong local authority/regional involvement support in the potential for job regeneration and regional development;

— local educational involvement whereby the skills necessary for the employees in the incubator can be introduced into the local curriculum;

— incubator units for developing fast track companies based on the research output;

— access to a science park where companies can develop after leaving the incubator so avoiding the need to leave the locality. Such a park also enables other service companies associated with the research sector specialisation to local nearby ("the food chain" effect).

Business Incubators in the UK

The number of existing incubators in the UK is quite small. There are however some notable success stories in the development of innovative new companies commercialising research or new ideas, eg Aberdeen Science and Technology Park, Warwick University Science Park, Oxford Centre for Innovation, St Johns Innovation Centre in Cambridge. These have established themselves as places where business incubation is a key factor in providing the supportive and instructive environment that new and growing ventures need if they are to reach their full potential. Many more new incubation projects are being developed or considered. The Panel's report identifies over 30 new projects currently being planned for or underway. In the next 2-3 years the numbers of business incubation projects are likely to significantly increase. Examples of these are the Manchester Bioscience Incubator, which is being developed by the School of Biological Sciences at the University of Manchester to develop small firms and incorporate ventures in the biotechnology/bioscience sector, Coventry University's Technology park developing the business ideas of its engineering and design graduates, and Cranfield University Technology Park specialising in the development of new ventures in the engineering and aerospace sectors commercialising research and ideas from the university and local large companies.

Business incubation projects can be groups broadly according to what they look like and what services they offer. The Panel identified, in its report, four general types in the UK.

These are:

— a *Technopole* where the incubator is an integral part of the development of a science and technology park, eg Aston and Warwick Science Parks, Aberdeen Science and Technology Park, Cranfield Technology Park;

— the *sector specific incubator* which develop businesses in a specific sector or type, eg Oxford Trust, Campus Ventures in Manchester, Cardiff Medicentre, Manchester Bioscience Incubator;

— the *general incubator* which has a mix of different businesses, eg New Work Trust in Bristol, Preston Technology Management Centre;

— and the incubator which concentrates on *building businesses* by creating management teams to develop specific commercial ideas, eg Lanarkshire Development Agency in East Kilbride, Univentures in Wakefield.

What is the difference between incubators and business centres or managed workspace?

Business centres are a well established and very useful feature of most urban and rural areas and they offer small work units with shared central services. A business incubator differs partly by offering more services to client businesses, but more fundamentally in its ethos. The Direcor of an incubator has a much closer and more hands-on relationship with client businesses; he/she will choose businesses meeting certain requirements (eg a promising business plan for growth), will encourage them to leave the incubator (and move to a science park or elsewhere) when they are ready and will be judged by the success of those businesses helped.

Corporate Venturing

Corporate Venturing is another form of business incubation, where large companies help the foundation and development of small companies in a number of different ways. The relationship between small and large companies aims to:

— share risks associated with innovations;

— generate new business opportunities;

— make best use of skills and resources of both parties;

— achieve business objectives of both parties more quickly and more effectively.

Existing companies are a potential source of research and resources to aid the establishment of new ventures, including spin-offs and contracted-out supplies and services. This is not merely altruistic. Particularly in fast developing areas such as pharmaceuticals or communication, corporate venturing can be of great value to the large company as a means of keeping in touch with a wide range of new developments which may impact on the future on its existing core business. Whilst corporate venturing has been undertaken by some pharmaceutical companies in the UK there is considerable scope for its promotion and development. In the USA such activity and relationships between large and small companies is much more prevalent.

Action needed

Not enough is generally known about the benefits which can be derived from business incubation. It needs a higher profile. Furthermore there is a need for more effective networking of experiences in establishing and running successful incubators and communication of basic data, such as sources of finance, and an analysis

of the benefits which client companies have experienced in an incubator. Both the public and private sector need to be shown how effective business incubation can be and in particular the benefits that can come from co-operation between the private and public sectors in this area.

The Enterprise Panel's main recommendations

The Panel's principal recommendation is that a Business Incubator Centre should be established in the UK which will act as a catalyst and facilitator in extracting maximum benefit from the business incubation process. This would be a small unit, based on a science park, whose role would be the effective promotion of incubators, better networking and the encouragement of private sector involvement. In the UK while there is a lot happening (the Panel's report identified over 30 new incubator projects planned for development over the next two—three years) there is a great deal of "reinventing of the wheel". Developing the Incubator Centre will ensure that new or established incubators in the UK will be more effective in ultimately improving the formation, survival and growth rates of early stage businesses, particularly those with the potential for growth.

The Panel's report also emphasises the positive role that private industry can play, particularly through participating in the financing of business incubators and through corporate venturing. The report comments on methods of making available public sector funding for the creation of incubators and emphasises the important role of accountants and solicitors in encouraging and enabling the operation of groups of business angels to supply equity finance to client companies.

Steps taken by the Panel

The Panel have been sponsored by Midland Bank for a further year to implement the recommendations in our report. The Panel's primary objective is to establish the Business Incubator Centre, the main recommendation of our report, but we are continuing to help new incubation projects develop and promote the benefits of business incubation to public and private organisations (eg speaking at the Bank of England/CBI/RSA conference in March).

The Incubator Centre will be an independent body, sponsored by private and public funds, which will work in partnership with and complement existing related business support organisations, eg UK Science Park Association, UK Business Innovation Centres, TEC National Council, Business Link Network and regional development agencies. The Incubator Centre will have a limited life; it will aim to achieve its objectives within a three—four year period.

The Incubator Centre will have four main objectives:

— Identify and promote best practice for new and existing incubators, in terms of finance, management and marketing skills and technology transfer;

— Explore and encourage partnerships in incubation, eg involve universities, business schools, venture capital companies and commercial companies in mentoring;

— Raise the profile of business incubation, inter alai by involving relevant organisations (eg UKSPA, UK BICs, Business Links, TECs) in the Centre's work and ensure that incubators are fully integrated into local business support/technology transfer networks;

— Set standards and training for and raise the profile of incubator directors.

The Panel have bid for funding through the DTI's Sector Challenge and have been successful in being invited to make a full bid. We are making progress in seeking to match this funding by sponsorship from private individuals and companies. The Panel are also seeking support from the EU.

12 January 1997

Letter and Memorandum from the Environment Agency

I am writing to you as deputy chairman of a sub-group established by the Technology Foresight Panel on Natural Resources and the Environment (NRE) to consider the barriers to innovation and exploitation of research and development in that particular sector. As explained in the NRE Panels Key Recommendation Report (1997), current world markets in this sector are about £100 billion.

Various commentators within this sector, including the predecessor panel's 1995 report on Agriculture, Natural Resources and the Environment, have drawn attention to the need to improve exploitation. The sub-group's aim is to promote the exploitation through an improved understanding of the process of innovation and exploitation and of the opportunities and barriers which exist.

As well as responding to your specific questions below on the NRE sector, I am attaching a paper prepared within the sub-group on overcoming barriers to exploitation in this sector. The paper was prepared following a consultative workshop organised by the Natural Resources and Environment Panel in May 1995.

Replies to questions:

1. The NRE sector and the UK is varied. Some industries are at the forefront of innovation, while others—notably SMEs and some of the newer environmental industries—struggle for reasons discussed in the paper as (a) organisational factors, (b) social issues, and (c) financial drivers. Clearly the overall position could be improved.

In particular, there remains inadequate investment in the processes of developing and exploiting the applied research, or in transferring technology from other sectors.

2. DTI and DoE initiatives have increased awareness, but understanding of the overall processes of innovation still needs improvement.

3. Provided these initiatives are sustained, they are clearly capable of success. However, many of the industry-academia partnerships in the public sector research programmes lack the follow through to exploitation (see 1. above).

4. Financing certainly needs to be improved. See "Financial Drivers" and "Financial Barriers" in attached paper. In particular there is a need for more flexible public-sector financing for projects demonstrating proof of concept of new environmental technologies.

5. Improved consumer awareness and also better communication between academia, industry (or end-users) and the financial sector. The sub-group has backed strongly the NEST project (see "Organisational Barriers" and NRE Panel 1997 Report) on creating an improved connection between these players.

It is also supporting work which better characterises the process of innovation so that there is better awareness of the essential elements (see 1. above).

6. Yes. See attached papers on Barriers, particularly "social" and "financial". Incentives for start-up, and better awareness of the players and process would help considerably.

7. Tax credits for R&D would, in the sub-group's opinion, be an effective way of fostering innovation. The Environmental Services Association is now taking forward an R&D Environmental Body to fund waste industry R&D through the Landfill Tax Scheme. See also p.4 of attached paper concerning externalisation of other natural resources and environmental costs.

8. There is no doubt that by focusing on "wealth creation" and "quality of life", the Technology Foresight exercise has heightened the general awareness of the need for end-use "pull" to assist innovation in research. This has improved the overall applicability of research and not markedly affected high quality curiosity-driven research.

9. It is difficult to say if tax relief has had the effect, but there is certainly increased awareness of the need for continuous professional development in the sector.

I hope that these responses are of interest. Please contact me if I can be of further assistance.

Mervyn Bramley, Head of R&D

14 January 1997

TECHNOLOGY FORESIGHT: NATURAL RESOURCES AND ENVIRONMENTAL PANEL

Overcoming Barriers to Innovation and Exploitation

What do we mean by innovation?

Innovation is the whole process of generating and introducing new products and processes to the market. It is not the same as invention, which is a pre-condition of innovation, but which can take place quite independently of the market. Innovation can only be successful if it takes into account the fluctuations and variations in demand which characterise the market and which result from the complex processes of interaction, continually taking place between Government, business and the public. Successful businesses are those which, either by good luck, or through careful study of this interaction—or both—anticipate or stimulate changes in demand and introduce the products and services which the market wants, enabling a company to keep ahead of its competitors.

How do we stimulate innovation?

The success factors which lead to innovation may be considered under three general headings: organisation factors; social issues; and financial drivers.

Organisational Factors

In order to understand how organisational factors can influence and dictate the success of innovation and exploitation it is necessary to first understand the roles of each of the component parts.

Public opinion is the name given to the ever-changing pattern of preferences which we try to measure by public opinion polls, elections, analysis of statistics, and other avenues of public expression, such as pressure groups. These preferences are influenced internally by personal experience and by the information provided

through the various channels of communication, and externally by objective changes such as population growth, climate change, resource availability and so on.

Although the market provides the stimulus for change, and is the principal determinant of innovation, it is itself only the reflection of the complex process of interaction between pubilc opinion, business and Government, which is continually taking place, both within and outside the market place.

Business acts to promote behaviour that is motivated by exclusively economic considerations, weighing every decision commercially in the light of assessments of personal financial gain or loss.

Government is the ultimate arbiter because it has the power to set the parameters within which the market functions. In a democratic system the principal influence on Government's actions will be the perception of public opinion held by the ruling politicians. Regulation arises from Government and from international commitments. The degree to which regulations are enforceable, or enforced, varies according to many factors such as the nature of what is being required, the structure for enforcement and the desire to enforce and to be regulated. For example, the decision over whether to adopt effect-based standards has an impact on how those standards may be enforced. Such effect-based standards and regulations may, however, offer more flexibility—whilst ensuring that the environment is protected—and therefore greater opportunities for innovation. Governments will also monitor and assess information, but this is not the same function as regulation—although it may lead to regulations being set.

Innovation is, therefore, dependent on the behaviour of the market, which is in turn a function of the interaction between Government, business and the public. Between them these three protagonists determine the regulations which are made as well as the availability of finance and information, which together govern individual decisions on when, whether and how to innovate. The most powerful influences which determine market behaviour are thus regulation, finance and the availability of information.

Overseas markets are clearly critical as opportunities to exploitation. In order to harness such markets, however, it is increasingly important to be able to put the right team together in a short space of time; hunting in packs is the way forward for flexible, cost-effective delivery to meet increasingly varied requirements by the public and business community. This is also true in the UK where, for example, companies are demanding whole solutions to their environmental problems, rather than simply bolt-on equipment. Furthermore, it is important that research focuses on problem solution rather than problem definition as is currently frequently the case.

"Organisational" Barriers

Organisational barriers to innovation and exploitation inlcude, amongst others, inadequate flow of information and lack of consistency in sources of information. Information is ultimately a strong determinant for change. Industry cannot make changes successfully if it does not have information about public demand and what is happening in the market place (not necessarily the same). The public cannot buy new products if they are not well informed and do not know about them. Government will not act unless it can be reassured that it will gain votes, or at least not lose them, by introducing change. The market cannot respond to external events unless it is kept fully informed of them. Continuously up-dated knowledge of events and developments all round the world is the life-blood of the market, on which its efficiency depends. The internet now provides excellent opportunities for the relaying of information about the latest technology to those who need it, and enables communication process to be faster. NEST will play a key role in enabling local authorities and other investors to identify and investigate all available options for innovative solutions to their problems. It will also provide a vital link between pure and applied research, government, and industry.

Many strategic policies are the result of out-of-date political assessments of public opinion, business interests and economic reality. An up-dated and radically revised assessment would indicate the need for drastic changes in policy, which would remove major barriers to innovation. If Government policies were to be based on a clearly stated and rationally formulated long-term strategy they could provide an important incentive for innovation. Consultative processes such as Technology Foresight, which aim to open lines of communication between Government, business and the public, can play an important part in developing such a strategy.

Concentration of political and financial power constitutes a further barrier to innovation. It is now generally recognised that SMEs are vitally important in generating innovation but they often lack the power and the financial resources to introduce their inventions to the market. Local authorities should be at the forefront in experimenting with new ways of solving problems at the small-scale local level but they seldom have the necessary power or money to make innovations. Decentralisation encourages diversity and increases the opportunities for experimentation in new ways of solving problems.

Social Issues

Social issues are commonly underestimated regarding their impact upon the success, or otherwise, of new innovations. They encompass a wide variety of factors, such as attitudes to change by industry, researchers, Government and others; the up-take of new mechanisms of communication; and perceived and actual pressures of time—especially for SMEs.

Corporate culture, as well as structure, plays an important part in the exploitation and up-take of innovative technologies and ideas. It requires confidence and non risk-aversive mentality to make the most

of new opportunities. For many on the borderline of financial stability, and for those with "to much to do" these seem like added business requirements, whereas they should be part of everyday business.

Public attitudes to environmental issues have not gone away either, although environmental issues appear to be lower down the Government's agenda than was the case six years ago for example. The capacity of the public to be hypocritical has been marked by recent public attitudes towards natural resource utilisation. One example of this is that now consumers are more directly paying for water consumption they see adequate supply as a right, regardless of the potential effects both upon natural resources and the local environment.

Social Barriers

Vested interests, complacency and inertia form strong social barriers to innovation. The primary move to avert and displace social barriers to innovation—exploitation would appear to be through education—both early on through schools and universities, and through ensuring continued on-the-job training. The high increasing rate of change should in itself demonstrate that the main requirement is to have an open mind and to be willing to accept change.

Financial Drivers

Finance is always limited and decisions as to its allocation between competing ends therefore determine the outcome in terms of production for the market. Although investment decisions and the allocation of finance are in the sphere of business operation, the Government is always the largest single player and, through regulations, determines ultimately how financial decisions are made.

Financial Barriers

Unless there is stimulus for innovation the pace of change will be at best lethargic. The most common stimulus is competition, actual or anticipated, which threatens to steal your market away with a new and better product. But if the market is sheltered from the chill wind of competition, or is distorted by other external factors which conceal the need for change, then there will be little incentive for innovation. Conversely, protection against monopoly and vested interests may be essential in certain circumstances to allow innovation a chance to take root and compete.

The principal reason why so many companies give low priority to innovation is cost. If people are buying your product why waste money on researching and experimenting with ways of changing it? After all, innovation does not necessarily imply improvement—we all know of "new, improved products" which are worse than the originals.

Applying the internalisation of costs to natural resources and environment it is possible to identify a number of barriers to innovation, which need to be progressively dismantled. One is the assumption, still widely held, that natural resources are free and can be exploited or damaged by Governments, businesses or individuals without charge. Externalisation of costs prevents the true cost of development being weighed against the benefits, with consequent distortion of the market. If these costs were charged correctly to those who incur them it would provide a major incentive for change. For example, if the costs of congestion and pollution were charged to car drivers and subsidies removed from business cars it would release funds for improving public transport and at the same time provide incentives for the introduction of improved, cleaner technology. Such changes need to be implemented over a period of time.

Similarly exclusion of natural resources from the national balance sheet distorts the nations accounts and removes the incentive at Government level to conserve limited and vulnerable natural resources. The introduction of these fundamental changes in the economic ground rules would provide powerful support for innovations which would reduce pollution and waste and enable us to do more with less—to make our resources go further with less damage to the environment. Until these changes are made the current economic conventions will continue to constitute a major barrier to innovation by subsidising and protecting existing technologies.

An overall reassessment of Government strategy in relation to the conservation of natural resources could also lead to major changes in taxation. Ecological tax reform, involving a strategy for the tax-neutral switching of tax away from added-value and onto subtracted-value, over a period of time, would encourage more use of renewable resources, including labour (thus reducing unemployment) and less generation of waste. The effect would be to convert existing barriers to innovation into incentives for change.

A strategy aimed at doing more with less would enable business leaders and SMEs to plan for a longer-term future and would help enormously in overcoming the short-termism and vested interests which can create barriers to innovation in industry and business. Accurate accounting, which internalised costs that are now left for the environment and the public to meet, would radically change the basis of cost benefit analyses and give industry a powerful incentive to innovate. The knowledge that the Government has embarked, for example, upon a consistent policy of increasing charges on waste and pollution over a period of years would allow industry time to plan the changes that this would necessitate and choose the best and most appropriate technologies.

The competitive challenge system of awarding funds to those local authorities which propose the best capital investment programmes could be adapted to encourage the achievement of specific targets by introducing new clean technologies which support the Government's environmental strategy. This would encourage the search for new technologies and at the same time enable such technologies to be introduced as pilot schemes. In the private sector tax incentives need to be given to encourage innovation by allowing accelerated depreciation on approved innovative investment and concessions on venture capital investments in such technologies.

Financial incentives to encourage innovation and further take-up of existing opportunities is also an important instrument to be played, for example, the advent of the new landfill tax will further waste minimisation practice into the business community.

Letter and Memorandum from the Environmental Industries Commission

Further to my phone call to you last week, I am enclosing a further memorandum on behalf of the Environmental Industries Commission by way of evidence to Sub-Committee II of the Science and Technology Committee in connection with its enquiry into the Innovation-Exploitation Barrier.

I apologise for not being able to get this to you by the due date, but I hope that this will not prevent the members of the Sub-Committee being able to consider its contents.

Inevitably, given the nature of the issues dealt with, it focuses on some quite detailed legal points. However, with one possible exception, I believe I can safely say that what is said as a matter of law is not contentious and would be widely accepted. The concerns we would like the Sub-Committee to be aware of are the consequences of the legal situation for those wishing to develop environmental technologies. The one possible exception, where a contrary view of the law might be expressed, is how flexible an interpretation can be given to "BATNEEC" when setting conditions for licensing certain "prescribed processes", as discussed in Section II (paragraphs 9 to 22). As we have indicated in paragraph 16, even if the Environment Agency accepts a more flexible interpretation than we think is strictly correct, local authority officials cannot be relied on to do so, which gives rise to the problems that the memorandum addresses in this section.

Richard H Burnett-Hall

I. *General*

1. The Environmental Industries Commission (the EIC) was formed a little over two years ago to represent the interests of the United Kingdom environmental technology and services industry, and to promote its international competitiveness. The EIC currently has 160 members representing the main environmental sectors (water, air, waste, land and noise, and environmental consultancies), and as such is the only umbrella trade association in the United Kingdom for the whole of this industry.

2. There are a substantial number of working groups in which members of the EIC take an active part. One of these, the Research and Development working group, has already supplied to this Sub-Committee a report commissioned by the EIC and published in March 1996, entitled "Barriers to Investment by the Environmental Technology Industry in Research & Development". The present memorandum is based on a paper prepared by the EIC's Legal Services group on legal and administrative barriers to the development and introduction of new environmental technologies in the United Kingdom.

3. In many respects, of course, the commercialisation of innovative environmental technologies must overcome the same problems as face any other new technologies. However in the environmental field there is a mass of regulatory controls that have, quite properly, a significant effect on what technologies are in fact adopted by industry. This paper accordingly focuses on the manner in which the regulatory controls are liable to favour existing technologies and to operate adversely to the introduction of new ones.

4. Before looking at individual issues, we would like to make it clear that we fully accept that there is a general wish to support the introduction of new environmental technologies, both in the Government and among officials in the Department of the Environment, the Department of Trade and Industry and the Environment Agency. Our concern is that in practice, the manner in which the regulatory controls have been designed and are implemented in the United Kingdom can often discourage this in fact. We have presented drafts of the Legal Services Group paper on which this memorandum is based to members of both the Department of the Environment and the Environment Agency. We appreciate their willingness to discuss these issues with us, and hope to have a continuing dialogue with them. Nevertheless we fear that these institutions, being short of resources and with numerous other commitments, are liable in practice to have grave difficulty in providing rapid and definitive solutions to meet industry's requirements, without the reforms suggested in sections IV to VI below (paragraphs 25 to 37).

5. We would also wish to emphasise here that we are not of course seeking higher standards and tougher regulation for the sole purpose of boosting the environmental technology industry sector. New technology in this field is not worth having if it does not provide genuine economic advantages to those who use it (though there may initially be a stage where official encouragement is needed to enable the growth that allows necessary enconomies of scale to be realised). Nevertheless, if standards are going to rise—and we believe

that they certainly have not yet reached a plateau in this country—then the United Kingdom environmental technology sector will be at a substantial disadvantage compared with its competitors in a least the USA, Germany and Japan, if the standards and degree of enforcement in this country lag behind those elsewhere. The end result will be for its competitors in the USA, Germany and Japan to continue to develop market share, both of their domestic markets and of the world-wide market, at the expense of the United Kingdom industry.

6. While environmental regulation inevitably has a direct cost impact on an industry sector that is required to comply with new regulations very rapidly, the proper conclusion is that adequate advance notice should be given, allowing technology suppliers time to develop new systems, and users to take the prospective new regulations into account when determining capital expenditure and plant maintenance programmes. The benefit of such an approach is almost entirely lost however if introduction of the new regulations is subsequently postponed, and the industry sector affected is in practice able to assume that it can always count on being given extra time to achieve compliance. The technology suppliers then see the markets for their goods and services, that they have budgeted and invested for, removed at a stroke, with potentially disastrous financial consequences, particularly for the smaller organisations with modest resources who are typical of those developing new technologies. Because the affected sector is almost inevitably long established, it may well have sufficient political clout to secure postponement of what it is liable to regard as a burden, whereas the various suppliers to it, often being relatively young and still growing, do not necessarily have equal weight where the decisions are taken. One of the main objects of the EIC is to redress this imbalance.

7. The evidence is in any event overwhelming that substantial, and often quite dramatic, savings in costs can be achieved by industries that are subjected to rigorous environmental regulation, as a result of managements re-thinking the processes that they operate. The consequences may be, for example, to reduce, or even eliminate, various waste streams, or to devise new processes that avoid altogether the production or use of substances that have to be tightly controlled. Such new technology may then in turn be profitably licensed to others. Moreover the experience is almost universal that where a manufacturing plant is required to pay careful attention to its environmental performance, the consequent rise in the standard of "housekeeping" at the plant almost invariably leads to very significant improvements in overall efficiency.

8. Higher standards of environmental regulation do not therefore necessarily represent an add-on cost, inevitably creating additional burdens for manufacturing industry. Even where there is an additional cost, if this properly reflects the polluter pays principle, and is the minimum cost reasonably necessary to avoid or reduce environmental damage that would otherwise cost the community at least as much (of properly costed, so as to include the admittedly difficult to value social costs), then this is a legitimate cost to require industry to bear. The polluter pays principle is of course one of the central principles of environmental control, being spelled out in Article 130R(2) of the Treaty of Rome, and a basic element of United Kingdom environmental policy.

II. *The Control of Prescribed Processes under Part I of the Environmental Protection Act 1990 (the EPA)*

9. The controls under Part I of the EPA apply to processes prescribed under section 2(1). These processes are detailed in the Environmental Protection (Prescribed Processes and Substances) Regulations 1991, as amended, and are the subject of the Chief Inspector's or the Secretary of State's Guidance Notes, depending on whether they are Part A or Part B Processes. (Part A processes are generally larger scale and the more polluting processes.) These Guidance Notes describe, in accordance with section 7(11), what techniques and environmental options may normally be taken to represent BATNEEC (Best Available Techniques Not Entailing Excessive Cost) for each of the processes concerned. An authorisation will incorporate conditions that spell out the principal BATNEEC requirements for the process in question—in so far as they are silent on any particular feature, section 7(4) imposes a general requirement to employ BATNEEC in that respect.

10. This approach is appropriate where a prescribed process is operated with a view to making a profit from that operation. However where a person aims to develop new technology, for use in a prescribed process, with a view to improving what is currently regarded as BATNEEC, enforcement of the legislation is liable to discourage or even stifle any such initiative.

11. Firstly, a person attempting to devise a better way of operating a prescribed process must necessarily run his new process, and any prototype plant, on a trial basis. However, unless he has an authorisation to do this, he is committing an offence under s.6(1) of the EPA. If he applies for an authorisation, by s.7 the conditions imposed must require him to use BATNEEC, determined by reference to the relevant Guidance Notes. As this will reflect established best practice, the new as yet experimental system will almost inevitably not be accepted as being BATNEEC. If the law is applied strictly, he can therefore only comply with an authorisation if he abandons what he wants to try out.

12. Secondly, as a necessary part of developing process technology, it will often be essential to test the process plant to extreme limits to determine its performance under varying conditions, and in particular to test its robustness, so as to iron out so far as possible any defects that may arise in the course of regular commercial use. It is virtually inevitable that, in the course of such trials, defects will become apparent, and that there will be occasional mishaps leading to unwanted discharges. Such discharges are liable to be used

as evidence of the unauthorised operation of a prescribed process (or, in the case of an authorised process, non-compliance with the BATNEEC requirements), and consequently as evidence of criminal offences.

13. Quite apart from the directly adverse, and discouraging, consequences of this situation, a person convicted of such offences must be treated as not being a fit and proper person when applying for a waste management licence, and hence liable to have the application refused. Where the new technology is concerned with recycling or recovering waste, such a conviction is therefore capable of killing the prospects of the person developing it of ever being able to go into commercial operation with it. Though the enforcing authorities have discretion not to prosecute, and the Agencies, when considering a licence application, have discretion to disregard a conviction, the exercise of discretion is inherently not something that can be relied on. The risk of enforcement, and of its consequences, undoubtedly discourages commitment to developing any new technology that may be put at risk, and equally (perhaps even more) discourages backers from giving financial support.

14. In practice the staff of the Environment Agency will generally wish research and development work to succeed, and are likely to choose not to enforce the law in such circumstances, if there are no strong contrary pressures on them. However for a person, particularly an individual or a small company, to feel secure enough to invest substantial time and capital in an R & D project, which is anyway bound to entail considerable financial risk, he needs to be given the maximum assurance that he will not be breaking the law unless he either behaves negligently—the bulk of the standard environmental offences are ones of strict liability—or allows emissions that are clearly unreasonable, in terms of both time and amounts, having regard to what is being attempted. It is not enough to be told that discretion will probably be exercised favourably.

15. This problem is especially acute where the process in issue is a Part B process, as it then comes under the control of the local authority, as regards emission to air, and not the Environment Agency (except in Scotland). Local authority officials may of course be very positive towards an R & D project, but they have less direct interest in encouraging new technologies nationally, and are much more exposed than the Environment Agency to local pressures against activities in their area that are liable to cause pollution. (That is precisely why local authorities retained control of air emissions from Part B processes, despite strong arguments that this should come under the new Agency, as was done in Scotland.)

16. As we believe the law to be, there is no scope for any prescribed process to be allowed to emit pollution at levels that exceed those that represent BATNEEC for that type of process. There is no provision for making exceptions for trial processes such as must be run in the course of research and development. This may in fact be done to some extent by the Environment Agency when authorising pilot processes, but we doubt whether this is strictly legitimate, and obviously those benefitting from any such liberal view of the law do not complain. However local authority officials are in our experience relatively unwilling to take a "robust" view of what the law requires of them, particularly if this may expose them to local opposition. (This may well be entirely proper, and is certainly very understandable. We do not complain of it, but observe it as a fact.)

17. The consequence is that research and development, particularly into novel types of Part B processes under local authority control, is liable to be faced with major difficulties if in fact any air emissions, however reasonable and modest, give rise to complaints from any members of the public. The powers to close down a prescribed process are substantial—contesting closure through the courts is unlikely to be a viable option for most small organisations—and the risk to a person's investments can be just too great for them to be prepared to pursue the necessary research and development. Even if the person wishing to conduct it is prepared to run the risk, banks and other outside sources of finance will generally be seriously discouraged by any potential threat of closure from supporting what would otherwise be seen as a worthwhile project.

18. For these reasons, as the United Kingdom legislation stands at present, it tends to have the perverse effect of forcing development to other more accomodating countries. (The United States, in particular, allows waivers from the strict enforcement of environmental controls over those involved in relevant research and development). If the development is forced abroad, ownership of the results is likely to stay there, to the benefit of that other country, and to the disadvantage of the United Kingdom.

19. Those developing new technologies cannot of course expect to be totally exempt from the application of all environmental controls, and particularly not from civil actions for nuisance or negligence. It is however unrealistic to expect them to keep emissions, and operations generally, to BATNEEC standards when running new processes on prototype plant, particularly when testing the limits of that plant. Accordingly, we would wish the Environmental Protection (Prescribed Processes and Substances) Regulations 1991 to be amended so as to exclude quite generally from all categories of prescribed process any process the operation of which is incidental to research into or the development of process technology. Guidance could be issued on when such an exclusion would apply, if thought appropriate.

20. Such an amendment would ensure that the EPA Part I controls over prescribed processes are confined to those that are operated commercially with a view to profiting directly from their operation. It is perhaps open to argument that the current legislation should be so construed in any event, but not only can there be no certainty on this without a Court decision on the point, but until then the Environment Agency and the local authorities can certainly not be relied on to adapt this interpretation. (Throughout this memorandum references to the Environment Agency may generally be taken to refer also to the Scottish Environment Protection Agency, "SEPA".)

21. The development processes excluded by this amendment could and should normally be subject to

reasonable conventional controls on solid waste and on discharges to controlled waters and to sewer, as these need not present any material difficulty to those undertaking research and development. Discharges to air are, however, undoubtedly much harder to confine in all circumstances. For the same reasons, therefore, we would wish to see the local authorities, and the Agencies where appropriate, given the power to grant an exemption from the statutory nuisance controls of Part III of the EPA. The operator could simply be required to take prescribed reasonable precautions while his process technology was under development. There is a precedent for this in the Clean Air Act 1993, Section 45(1) of which enables a local authority to exempt any person, not only from the main provisions of that Act, but also from the statutory nuisance provision of the EPA, if satisfied that it is expedient to do so, in order to enable the conduct of investigations or research "relevant to the problem of pollution of the air". An amendment of that Act to delete those last words from the section would in fact do all that is necessary.

22. Essentially the same result could be achieved by appropriate amendment of Part III of the EPA (which relates to statutory nuisance) or, alternatively, by keeping research and development on prescribed processes within the scope of Part I, but relieving if of the BATNEEC requirements. Either way, this would require primary legislation, however, whereas what we have proposed in paragraph 19 would merely need a further Statutory Instrument.

III. *"Fast track" Licensing for New Technologies*

23. When a new technology has been developed then, depending on the nature of the technology, there may well be no previous experience of the environmental risks that its operation may pose. If the technology is to be exploited in several different regions of the Environment Agency, current practice requires the personnel in each region to consider separately what the potential risks are, and to frame a set of conditions to provide appropriate protection from these. This is bound to involve considerable replication of work both within the Agency and for the business that has developed the technology. (Even if it is the customers of that business who need to be licensed, in practice they will expect their supplier to reassure them that a licence is available on reasonable terms, and to assist in their obtaining licences should any difficulties arise.) The demands on the time of the technology supplier's skilled manpower are likely to be substantial, and yet are wholly unproductive in business terms, taking vital personnel away from the development of the business and from the working up of new operations.

24. We have been told that the Environment Agency is currently developing what it refers to as an "Ops. Help" system designed to provide support for its staff in the different regions, and to avoid unnecessary duplication by allowing the experience gained in any one region to be shared with all the others. We strongly support this move, and in this respect would merely wish to be assured, for the reasons just indicated, that this development will be given a high priority within the Agency, and brought into full effect as soon as possible.

IV. *The Licensing of "Mobile Plant" under the Waste Management Regime of Part II of the EPA*

25. To assist in commercialising new environmental technologies aimed at the efficient treatment of waste arising on a factory site, it will often be advantageous to be able to run demonstrations around the country. Waste management licences other than mobile plant licences are site-specific, and hence demonstration of a new form of waste treatment will ordinarily require a licence to be granted in relation to each site where the process is to be operated. As a practical matter this may often be commercially unrealistic, because of the length of time required for the grant of a site licence, which in turn requires planning consent to be already in place.

26. Accordingly, except where an exemption from waste management licensing is available (as to which see paragraph 28 *et seq.*), what is required is that the waste treatment apparatus be eligible for a mobile plant licence. However what constitutes "mobile plant" has to be decided by reference to a narrow definition contained in Regulation 12 of the Waste Management Licensing Regulations 1994, as amended. If people are to be encouraged to develop new technology that can be used as mobile plant, and if those providing financial backing are to be persuaded that the timescale for obtaining a return on their investment is reasonable and reliable, it is essential that the Department of the Environment be fully prepared to bring forward, whenever necessary and without delay, a Statutory Instrument amending the definition of "mobile plant" so as to extend it to cover any such new technology as has been developed.

27. Accordingly, if the present system for licensing mobile plant is to be retained, then we would wish to see the Department of the Environment identify a unit or an individual within it as being directly responsbile for receiving applications for amendment of Regulation 12 of the Waste Management Licensing Regulations 1994, and to publish this fact widely, encouraging applications to be made. However, we question whether it is necessary for there to be any specific restrictions on what mobile plant may be licensed and what may not, provided it is in fact mobile. We therefore see no need for sub-section 29(10) of the EPA, which provides for regualtions to be made to define what is or is not "mobile plant". Preferably therefore section 29(10) should be deleted and the reference to it in section 29(9) removed. Should it be felt necessary to keep this provision so as to be able to stipulate what is not mobile plant and therefore requires a site licence wherever it is operated that could be acceptable.

V. *Exemptions from Waste Management Licensing under the Waste Management Licensing Regulations 1994, Schedule 3*

28. Waste management licensing entails considerable expenditure of time and money in obtaining a licence, and substantial additional direct and indirect costs as a result of a requirement that the licensed activities be supervised by a qualified person who has obtained the essential WAMITAB (Waste Management Industry Training and Advisory Board) certificate. In practice at least two such people are needed, to allow for time off sick or on holiday, and for safety there needs to be a minimum of three certificate holders, in case the only one available of two is suddenly incapacitated. A large waste management company will need many certificate holders anyway so this is no major issue for it, but a small company developing eg, a novel composting process cannot necessarily carry sufficient staff with these qualifications. The relevant EU Directive 75/442 as amended, which is implemented in the United Kingdom by Part II of the EPA 1990 and the Waste Management Licensing Regulations 1994, basically requires all waste disposal and recovery operations to be licensed. However it permits exemptions from this licensing requirement to be granted to waste recovery, and some disposal, processes that meet certain criteria set out in the Directive—essentially those that are unlikely to lead to significant environmental harm. The processes that are exempted in the UK are those set out in Schedule 3 to the 1994 Regulations.

29. Many of the new environmental technologies being developed are environmentally more benign than those they aim to replace, and where these are concerned with waste treatment they will often meet the exception criteria as well as or better than many already exempted processes. However, being new processes, they may well not come within any of the categories currently exempted by the 1994 Regulations, and therefore require a full waste management licence before they can be operated, even on a small scale trial basis. Self-evidently it would greatly facilitate both research and development into, and adoption by the market of, such new waste treatment technologies if those using them do not need to apply for a waste management licence, with the costs, inconvenience and delay that that entails, including in particular ensuring that a sufficient number of people with WAMITAB qualifications are on the payroll.

30. Again therefore it is essential, if the necessary initial investment of expertise and finance is to be forthcoming, that the Department of the Environment be prepared, whenever new technology is available to be marketed that satisfies the criteria for exemption in the EU Waste Directive 75/442 as amended, to bring forward without delay amendments to Schedule 3 to the Waste Management Licensing Regulations 1994 that exempt the new technology so far as appropriate. Accordingly here also we would like to see a unit or an individual within the Department of the Environment be identified and given direct responsibility for revising Schedule 3 whenever required, and that wide publicity be given to this, along with encouragement to apply for new exemptions and/or appropriate amendment of existing exemptions within Schedule 3.

31. In practice, we cannot see any sound reason why responsibility for exempting new processes from waste management licensing should not be within the jurisdiction of the Environment Agency—if the Agency is competent to set the conditions of waste management licences, it must also be competent to define what does not require a licence at all. We would expect the Department of the Environment to need to consult with the Environment Agency in any event before it drafted any amendment to the Schedule 3 exemptions. Naturally any power given to the Agency to do this would have to be exercised within the bounds set by Directive 75/442 as amended, but it is undoubtedly already familiar with applying these, as it must already assess whether processes within the literal scope of any of the exemptions are in fact entitled to be exempted in any particular case.

32. If there were to be a concern that the Agency might be unduly strict in granting exemptions, the Secretary of State would of course continue to be able to amend Schedule 3 as he sees fit at any time. It would indeed be desirable, for the purposes of keeping the public properly informed, that Schedule 3 be updated on a regular basis, eg, annually, to reflect such exemptions as may have been granted previously on an individual basis by the Agency. We therefore recommend that the Environment Agency be given power to define categories of waste management operations that are exempted from the waste management licensing obligations.

VI. *The Definition of Waste and Special Waste*

33. One constant problem, that will recur ever more frequently as waste controls (and landfill tax rates) are intensified, and people devise new ways of turning to good use what has in the past been disposed of as waste, is whether, in a particular set of circumstances, a material must be regarded as waste, and hence subject to the controls of Part II of the EPA, or whether it is a useful by-product that is outside these controls altogether. Likewise there will always be situations where a holder of waste needs to know definitely whether it is or is not "special waste". The definitions of "waste" and "special waste" are both very imprecise, and far from straightforward to apply. A subsidiary question, that may on occasion also arise and need rapid determination, is whether the treatment proposed to be applied to a waste material is to be regarded as a recovery or a disposal process. Here again the statutory definitions of these processes, such as they are, do not provide a clear answer in many cases. (The answer has implications for whether and how the process should be licensed, and whether it may be exempted, if conducted away from the place of production.)

34. A company that wishes to comply with the law is left in limbo if it is unable to get rapid and authoritative decisions on these questions. It is neither fair to those honestly seeking to comply with the law, as compared with less scrupulous competitors, nor is it consistent with the Government's desire to avoid unnecessary regulation, to tell a company that is uncertain whether it is holding waste that it should play safe and to apply for a waste management licence. (This appears to be the standard response of Agency staff, who have a perhaps natural inclination to seek to control activities, rather than to accept that they can be operated without a licence.) As mentioned, getting a licence is not only liable to be both time consuming and expensive, but may well also require the recruitment of individuals with relevant WAMITAB certificates. If companies are obliged to wait for months for any effective determination of the issues confronting them, they are forced into the dilemma of either having to incur such licensing costs (quite possibly unnecessarily) or risk a criminal prosecution. This is clearly hostile to innovative businesses and requires an effective solution.

35. We would therefore like to see the Environment Agency set up forthwith an impartial, quasi-judicial, procedure for determining rapidly, in a manner that would be binding on all the regions of the Environment Agency and all other parties involved, at least the following issues, namely (i) whether, in a defined set of circumstances, a material is to be regarded as waste, (ii) whether it is special waste, and (iii) whether a proposed treatment of waste is a recovery or a disposal operation. There should also be a right of appeal to an appropriate tribunal. Challenging a determination of such issues by the Agency by way of judicial review is generally not practicable, due to the costs and delay involved.

36. The ability to categorise a material confidently as being waste, special waste, or neither, is moreover essential when transferring it to third parties, and the issue may also have relevance to eg compliance with planning conditions. It is therefore also important to have a determination that allows the holder of the material to deal with it without fear of inconsistent determinations of these difficult questions by other tribunals. We accordingly recommend that Part I of the EPA be amended to provide that any such determination by the Environment Agency, subject to the outcome of any appeal, would be conclusive in all other proceedings.

37. In this context we would note that an area where new technologies are needed, and could be readily encouraged by the Agencies, is in the field of testing for special waste. Methodologies for doing this have not yet been adequately developed, and there is much scope for the Agencies to formulate programmes and requirements that would have the effect of stimulating new technologies that would be of considerable benefit to industry, as well as aiding sound administration of the waste controls.

VII. *Financial Support by "Environmental Bodies" for Research and Development*

38. Under the Landfill Tax Regulations 1996, up to 20 per cent of amounts payable as landfill tax may be paid to an approved environmental body. To be approved, its objects must be or include any of those within Regulation 33(2). These include research and development for the purpose of encouraging the use of more sustainable waste management practices (an expression that includes waste minimisation, minimisation of pollution and harm from waste, re-use of waste, waste recovery activities and the clearing of pollutants from contaminated land). While we fully support this feature, the making of payments to an approved environmental body for this, or indeed any other, purpose is subject to two constraints. Firstly, the environmental body must be prohibited from distributing any profits that it makes and, secondly, the landfill site operator making a payment for such a purpose must not be entitled to benefit from the application of the funds, except to the extent that the operator is a member of a category of the general public that receives the benefit.

39. We believe that these restrictions are undesirable, and unnecessary, at least in relation to the funding of research and development. The funding of research and development is inherently a speculative process, and there is no certain return. If relevant research and development is to receive significant funding through environmental bodies, we believe that these constraints should be lifted and that those making payments should be entitled to receive benefits from any work that in fact proves to be successful—undoubtedly a significant proportion of the work will turn out to be wholly or partly wasted. We strongly advocate that money paid out of landfill tax to environmental bodies should be capable of being applied to research and development without further strings attached.

Memorandum by Glaxo Wellcome

EXECUTIVE SUMMARY

1. Glaxo Wellcome is a major UK pharmaceutical company which operates in the global marketplace, invests over £1.13 million on R&D activities and employs a significant number of scientists, engineers and technologists. The success of the Company is critically dependant upon its ability to harness advances in many areas of science and technology to discover, develop, manufacture and sell new medicines which offer real advances in the treatment of human diseases. Innovation lies at the heart of most of our activities.

The Barriers to Innovation

2. We recognise that the barriers to innovation are many and varied and will differ according to the industrial sector under consideration and even according to the nature of the different parts of a particular business. Factors creating barriers may range from cultural differences between potential partners, lack of scientific or technological expertise within organisations and failure to maintain awareness of relevant technological developments, to regulatory requirements and financial or economic considerations.

There is not likely to be a universal panacea which will remove all barriers and it is therefore important to understand the nature of the business, its requirements and industry-specific barriers.

Innovation and exploitation in Glaxo Wellcome

3. Examples are given of the exploitation of new scientific knowledge and emerging technologies within the research, development and manufacturing activities undertaken by Glaxo Wellcome.

(a) In drug discovery

The starting point in the search for new therapeutically active molecules has always been some degree of understanding of the disease process and the identification of molecules involved in normal and disease states. This knowledge, coupled with inventive chemistry, has lead to the discovery of major classes of medicines for human diseases. Recent advances in the molecular and cellular sciences, biotechnology, and genetics have opened the way to the discovery of curative medicines. To make full use of these we find that collaboration with academic researchers has become essential. This was an area in which there were many barriers to the transfer and exploitation of new knowledge and technologies; but these have now been minimised as a result of better mutual understanding between the two sides and the creation of effective partnerships. In effect our academic colleagues are regarded as an integral part of our medicines discovery process and become a part of the continuum between invention and exploitation, with the transfer of knowledge and technology between industry and academia as an almost seamless process. Old barriers are still sometimes encountered which can prevent exploitation, such as the premature and often inadequate patenting of inventions by HEIs. We are however beginning to see new barriers emerging. One of which is the declining infrastructure of the research base of the universities.

(b) In technology supporting Research and Development activities

The processes of drug discovery and development have become more complex and novel technological solutions are required to meet new problems. One barrier we have found which will prevent the exploitation of new technologies is that the company may not have the necessary specialist expertise to develop the technology required. There may often be a gap between potential users of technology and the supplier. Glaxo Wellcome has approached this problem in the analytical chemistry area, for example, by developing close links between our analytical chemists, who specify the new systems required, and various companies providing the equipment. We have created alliances with the producers and collaborated with them to develop their systems to meet our needs. In the end there are benefits for both partners.

We have recognised the importance of computer technology for many parts of the Company's activities and have made significant investments in creating the infrastructure and expertise in-house to enable us to make the best possible use of the existing, and emerging, potential of such technology to enhance our own capabilities.

(c) In Process Development

Any lead compound identified during the research process requires further activities in order to develop appropriate formulations, and sometimes new delivery devices, and to develop processes for its manufacture. In these areas there is scope for the application of new technology and innovation and thus there is a need to develop mechanisms to ensure that this happens. The Glaxo Wellcome R&D organisation is prepared to carry out, or sponsor, work to prove the concept when approached by outside bodies, whether academic and industrial, offering a soundly based technological opportunity. In one example our collaboration with academic researchers has lead to the formation of a spin-out company from the university to exploit the new development more widely.

In the case of development of processes for the large scale manufacture of a new chemical entity the scope for innovation has often been limited by the Company's available manufacturing plant which may constitute a barrier to the exploitation of new technology. However, circumstances do arise which require a new technological solution to be found to meet new problems, and the Company is developing mechanisms to ensure that it is in a position to take advantage of relevant novel technology capable of enhancing our process development and manufacturing capabilities. New technology is being exploited in process development to improve on the efficiency of the development laboratory and allow more rapid definition of the optimum conditions to achieve most effective large scale chemical transformations. In this field too we find that collaborating closely with equipment makers and harnessing their expertise and that of our scientists is the most effective route to innovation and exploitation.

(d) In Manufacturing

Once a process is established in a factory it may be difficult to introduce new technologies later to improve the process or the product. Any change to the process must be justified on business grounds, be shown to have clear benefits and quality of product and patient safety must not be compromised. Considerations such as these may constrain the potential to exploit new technologies. A further significant barrier to innovation is the highly regulated nature of the industry, so that introduction of a change to the established process would require the submission of a supplementary NDA to the regulatory authorities which can be a lengthy and costly process. There is however scope for the introduction of new technologies into the manufacturing area, and to foster this we have now created a group of some 200 people, drawn from a range of scientific and technological disciplines, charged with the task of identifying relevant new technologies and examining ways in which they may be exploited.

Government initiatives to stimulate innovation

4. Glaxo Wellcome, have long been active supporters of a number of Government or Research Council initiatives designed to encourage academic-industry collaboration, and thus the transfer of knowledge and technology. We operate collaborative PhD studentship schemes which currently support 278 PhD students, either through the CASE scheme or fully funded by the Company. We regard these as an important means of building bridges between us and our academic colleagues and the development of long term relationships between company and academic scientists.

5. The Company has been a participant in the LINK scheme since its inception, and has now been involved in over 20 different LINK projects and programmes, varying from small partnerships to programmes involving large numbers of other companies and academic departments. We have found participation in these projects can be an effective means of developing and sharing new scientific knowledge, and for transferring technology and research tools between the partners.

6. We have a growing involvement in European Union initiatives for collaborative research with research projects supported under Framework IV and technology collaborations through schemes such as "LIFE", which supports Community environmental policy. Such schemes can provide for "proof of concept" investigations and define the utility of new technologies and make them available for exploitation through the participants.

Effectiveness of initiatives to encourage collaboration

7. In our experience schemes, such as those mentioned above, together with collaborative support schemes operated by companies such as ours, have been effective in bringing about closer relationships between industrial and academic science and technology. The last decade has seen a marked, and welcome, change in the attitude of many in academic scientific research towards industrial science, with a greater willingness by many in academia to work on problems of relevance to industry. Schemes such as LINK have also been effective in achieving industrial synergies by bringing partners from different sectors together in collaborative research projects. They are also to be encouraged as a means of addressing generic or pan-industry problems and creating the "critical mass of interest" to achieve investment in the research to discover generic technological solutions. LINK has also provided a mechanism allowing companies from the SME sector to become involved as collaborators with large multinational organisations and academic centres of excellence.

8. Other recent schemes, such as the GR funding element devised by HEFCE, we believe to have been unhelpful. Similarly the various Government schemes recently introduced, without any prior consultation with industry, to encourage matching industrial funds to support academic infrastructure have been less than helpful.

9. Difficulties with UK Government and EU schemes designed to encourage collaborative research, technology transfer and exploitation of new technology lie in the bureaucratic nature of the arrangements and the rules of many schemes, which are often not clearly laid out. It is also becoming increasingly difficult to keep abreast of these schemes and to understand them and their relevance to company activities. We suggest that more effort is needed by originators of these schemes to ensure greater awareness and clarity of what schemes are available.

Other possible support systems to ensure maximum advantage of innovative ideas

10. It should be recognised that there are a number of potential technological advances made during the course of "blue sky" research in UK HEIs, which may be adaptable to other uses and be of commercial value. Likewise developments resulting from research in one area of science and technology designed to meet a particular need, may have application in areas beyond those for which they were developed. These circumstances have potential for the wider exploitation of technologies within different sectors of industry or commerce, including the SME sector. The problem lies in bridging the gap between the originator and the potential industrial/commercial developer. Ways need to be created of increasing awareness within a wide

range of industry or commercial sectors of technologies being developed elsewhere and encouraging new, or wider, uses for them.

11. Information Technology, and in particular the World Wide Web, is a means of bridging the gap between originators of new concepts and information and the potential users. This could be used effectively to create "catalogues" of available skills and technologies and for the transfer of information. We therefore welcome the creation of initiatives such as the Network for the Exploitation of Science and Technology (NEST) to exploit this approach.

12. It is frequently the case that concepts originating within academic laboratories are not of interest to potential industrial developers because there is insufficient data to support the concept. Academic groups may lack the resources, in terms of infrastructure and finance, to allow them to progress their invention to the point of proving the concept and defining its limits of utility. We suggest that the concept of the Technology Incubator, identified by a number of the Technology Foresight Panels, should be developed and expanded in the UK in order to provide the resources needed for this essential step.

13. The reluctance of Government to provide support for "near market" research, created a problem of funding for the development of new technology with potential commercial utility. Government schemes should in future avoid this danger, be more relaxed in the definition of "near market" and possibly develop schemes under which successful exploitation of technology leads to some pay back to the public purse.

The Influence of Technology Foresight

14. Glaxo Wellcome staff, mainly drawn from the Research areas, were involved in the general Technology Foresight consultation process, however the output from the Programme has had little impact on most areas of the Company outside the immediate Research areas. Glaxo Welcome R&D has for a long time maintained its own technology awareness mechanisms and there was therefore little in either of the two most relevant reports—"Health and Life Sciences" and "Chemicals"—that was not already known to us. The Technology Foresight exercise has not penetrated very far into this Company and we believe this to be a not unusual situation within the industry and our suppliers.

15. Glaxo Wellcome was a partner in six submissions for project support from the Technology Foresight Challenge fund of which only one was successful. We are however participating in the new initiative created by the Medical Research Council to address the problems of ageing which was highlighted by the TF exercise. Within the manufacturing parts of the company it is felt that those areas most likely to receive government support as a result of the Technology Foresight initiative, involving academia, are those at the "leading edge" of science; there seems to be less desire to fund the sort of solid technology development required by industry.

The maintenance of technological skills

16. We believe that an important factor which will determine the future ability of UK companies to harness and exploit new technologies, and be innovative, is the skills base of the workforce. It is important therefore that Higher Education Institutions (HEIs) provide training in science, engineering and technology of high quality and produce individuals with a good level of knowledge of their fields and the skills needed to practice their discipline.

17. The rapid change over the last decade witnessed in most areas of science and technology has set a pattern which is likely to continue well into the future. Thus to be in a position to be innovative, and exploit new scientific knowledge and technological developments effectively, it is important that the level of knowledge and skill in individuals is maintained at a high level throughout their working life. To ensure that lack of relevant skills does not create a barrier to exploitation it is necessary to encourage companies to provide continual training and reskilling for their staff at all levels, and for the HEIs to play their part in this process.

18. Glaxo Wellcome is committed to being a learning organisation in which opportunities are given for all members of staff to continue their development and acquire new knowledge and skills. We therefore are developing resources to allow sharing of ideas and information and spreading new knowledge throughout all parts of the organisation. We also provide courses to develop the various competencies of our staff and their career progression.

The Knowledge Gap as a barrier to exploitation of technology

19. The scope of new technology is now very broad and has potential application across a range of different industrial, or indeed academic sectors. The division of science and technology into pigeon holes will deny the maximum use, and thus benefit, of new technologies. It is important to look across disciplinary boundaries, and often into areas of science, engineering and technology which are quite far removed from the organisation's, or individuals' own interests and activities. However, the organisation of many institutions, industrial or academic, is still much along the subject discipline lines and this creates a "knowledge gap" which impairs the acceptance of new ideas and so can present a real barrier to innovation and exploitation.

20. A "knowledge gap" usually arises where those needing to bring about the change usually know what is required to solve the problem, but do not have sufficient breadth of knowledge or expertise to be able to provide the solution; others may be unaware of the problem but do have the skill and experience to provide the solution. In our experience this gap can be closed through creating alliances with other organisations in our various supply chains who are more usually seen as providers of equipment, resources or services. They must be seen instead as partners actively working to achieve synergies to provide innovative solutions.

21. Companies must be prepared to recognise the core competencies and technologies of their suppliers as having value for themselves, and developing mechanisms to exploit them to solve problems across a range of their activities. In order to promote such alliances however it is important that the partners clearly understand each others' position, understand the problem for solution and be able to work together in an open fashion, sharing ideas and developing new concepts throughout the process of building, evaluating and modifying the desired product. The development of "Supply Chain Management" processes would help in this context, and this would lend itself to a collaborative project approach with partners from different sectors coming together to share experiences to define the issues and identify best practices and potential solutions.

22. There is considerable potential in the development of new schemes and initiatives designed to engineer the closing of this knowledge gap and so bring about the more effective exploitation of innovative technology. We welcome the recent initiatives being developed by the Research Councils and EU to promote better understanding of manufacturing processes and industry issues.

1. Introduction

Glaxo Wellcome is one of the three remaining UK major pharmaceutical companies and is now the world's largest pharmaceutical company by sales. In addition to supply effective medicines to treat many human diseases, the UK's pharmaceutical industry is a major contributor to the country's economic well being. In 1995, for example, the gross turnover was about £11.8 billion, of which nearly £5 billion was earned from exports. The success of the UK pharmaceutical industry has for long been dependant upon its ability to discover new and innovative chemical compounds with the potential to be therapeutic agents for human diseases, and then to develop these compounds as medicines by demonstrating their safety and clinical efficacy. These activities are firmly based upon a foundation of science and technology and the Industry is therefore one which invests heavily in research and development activities. The pharmaceutical industry is responsible for about 24 per cent of all R&D spending by UK manufacturing industry. In 1994 the industry spent about £1.9 billion on R&D which represented about 18 per cent of turnover which is significantly higher than most other UK industrial sectors; many of which invest less than 6 per cent of turnover in R&D.

Glaxo Wellcome had sales in 1995 of over £7,600 million and spent over £1,130 million on its R&D activities. We operate in the global marketplace with Glaxo Wellcome companies in over 83 countries. Our research to discover new medicines is carried out on an international basis in our laboratories in the UK, USA, Italy, Switzerland, Spain, France and Japan. We also have collaborative research centre in Singapore which is jointly funded by Glaxo Wellcome and the Economic Development Board of Singapore. Our major primary manufacturing sites are in the UK and Singapore. Like other companies in the pharmaceutical industry, our success in discovering, developing and manufacturing new medicines is critically dependent upon our ability to harness advances in science and technology creatively and effectively. We therefore employ a significant number of scientists, engineers and technologists, and in particular have about 3,600 graduate or doctoral scientific staff in our UK R&D organisation (GWR&D).

Innovation lies at the heart of most of our activities whether they are directed towards the discovery of new therapeutically active molecules, innovative delivery devices or the packaging of the products for the world-wide marketplace. Thus we believe that innovation, whilst encompassing invention, goes far beyond this. It involves the development of new technologies to further our research to discover new medicines, or the manufacturing processes used in their production. It also includes the adaptation of existing technologies to meet new needs, or the application of such technologies to perform particular functions more effectively. Innovation need not necessarily involve technology at all and may merely be the development of different and more efficient or effective practices within the business. This paper will, however, be confined to addressing innovation as it relates to the application of science and technology. Within the pharmaceutical company innovation, in the sense of invention, will be most critical at the discovery stage. New scientific knowledge and the application of novel technologies is at the heart of this process providing fresh insights into disease processes, indicating potential novel therapeutic interventions and providing new tools for use in the discovery of active molecules. However, there is also considerable scope for technological innovation in many of the other activities within the organisation; new technologies may allow more effective development of a new medicine, such as for example, the creation of better formulations for the drug substance or novel delivery devices. There is also a need to devise more efficient means of synthesising active drug substances safely on a large scale in the factory. Technology may also provide new approaches to packaging the medicines which may differentiate the product in the marketplace and confer competitive advantage.

We provide below some examples of the innovation-exploitation gap that have been experienced across a range of different functions, from R&D to the finished product, within Glaxo Wellcome's UK companies. We also give some account of some of the solutions that we have found to close the gap.

2. The Barriers to Innovation

The barriers to innovation are many and varied. They will differ according to the industrial sector under consideration and they may differ according to the nature of the different parts of a particular business. In our experience factors creating barriers may take a variety of forms including:

- cultural differences between potential partners leading to unrealistic expectations;
- a lack of scientific or technological expertise in the company to enable it to understand new developments and identify the opportunities in them;
- a failure within the organisation to maintain an awareness of technological developments which may have relevance to the business;
- the fear of innovation leading to "mission drift";
- a knowledge gap between user and suppliers;
- regulatory requirements, and
- financial or economic considerations.

There is not likely to be a universal panacea which will remove all barriers. If, therefore, ways of removing the barriers, and creating bridges between innovation and effective exploitation are to be discovered, it is important to understand the nature of the business, its requirements and industry-specific barriers.

3. Innovation and Exploitation in Glaxo Wellcome

(a) *In drug discovery*

Glaxo Wellcome and other pharmaceutical companies have been successful over many years in the search for new therapeutically active molecules. The starting point has always been some degree of understanding of the disease process, or more particularly the identification of molecules involved in normal and disease states. As examples of such molecules we may cite, nor-adrenaline or renin and angiotensin in the case of hypertension, histamine in the case of allergies and gastrointestinal ulcers, dopamine in Parkinson's disease, serotonin in emesis and migraine. This knowledge, coupled with inventive chemistry, has led to the discovery of major classes of medicines for human diseases.

Until the mid-1980s pharmaceutical research organisations were largely self-sufficient in having the scientific and technological manpower to discover active compounds, most of which could be proved using appropriate animal models. Thus the innovation (invention), and the activities required to exploit it, formed a continuum being carried out within the same organisation. Provided that the invention had the potential to provide a safe and effective medicine, and assuming no flaws were subsequently found, the barriers to successful exploitation of that compound, or an improvement on it, if they existed, were low. Problems were encountered when the invention was made elsewhere, particularly if it originated in an organisation without the resource to develop the compound into a product. Often these difficulties had their root in the different views of the utility, or value, of the invention being taken by the inventor and the potential exploiter. There are a few examples of compounds discovered in academic laboratories which have been successfully developed by a company—such as Atracurium which was discovered in the University of Strathclyde and developed by the Wellcome Foundation. However, many more "inventions" made within academic laboratories have failed to be developed for a variety of reasons, chief of which have usually been lack of real utility, the prejudicing of intellectual property position by premature publication or inappropriate patenting.

In the last decade the self-sufficiency of the industry has been diminished. This is a result of advances in the molecular and cellular sciences, biotechnology, and now, genetics, which have opened the way to understanding disease processes and mechanisms in a way that will allow the discovery of curative medicines. Collaboration with academic researchers has therefore become essential. In 1989 Glaxo established an External Scientific Affairs Department charged with the task of establishing joint projects between the Company's scientists and colleagues in academic laboratories. Over a period of about five years we were able to develop a greater mutual understanding between the two sides and to create effective partnerships; with the Company providing significant funding, to carry out the fundamental strategic research to underpin our drug discovery programmes. We believe that many of the problems that had created barriers between ourselves and the academic institutions have largely been removed, and in effect our academic colleagues are regarded as an integral part of our medicines discovery process. In the event that their contribution leads to new products, they will be rewarded. Thus the academic partner has become a part of the continuum between invention and exploitation, and the transfer of knowledge and technology between industrial and academic scientists becomes an almost seamless process.

Although we now find that most of the old barriers between academia and industry, which were largely attitudinal, cultural or financial, have been removed some do still remain. For example, premature patenting of inventions by HEIs is still occasionally a problem which can prevent exploitation. There is sometimes a conflict between the role of the academic Chemistry Department in the prosecution of leading-edge scientific research and the demands which may be made upon them by the HEI's Industrial Liaison Office to patent new compounds. Thus they can come under pressure to divert their activities in order to synthesise chemical

analogues to exemplify the invention. Inadequate exemplification leads to weak patents and unexploitable inventions. We strongly recommend therefore that the academic researchers discuss their invention at an early stage with a potential exploiter with the expertise and skills to develop and execute patenting strategies leading to the strongest possible position for the entity. Appropriate Confidential Disclosure Agreements should be used to ensure security of the invention during these discussions.

We are now beginning to see new barriers emerging. One of these is the declining infrastructure of the research base of the universities. Increasingly we are finding that UK academics are unable to carry out the studies required because they lack the necessary state-of-the-art equipment and facilities; as a result of this we are finding that a significant, and rising, proportion of GWR&D's academic collaborative project funding is being used to support projects in universities overseas. In 1996 27 per cent of our budget of £10 million went overseas compared with 5 per cent of £6 million in 1988–89.

Government schemes, such as CASE and LINK, which engendered collaboration between academic and industrial laboratories have undoubtedly aided in the process of bringing the two different cultures together. Our experience of these is discussed below.

(b) *In technology supporting Research and Development activities*

As the processes of drug discovery and development become more complex problems and issues arise which require novel technological solutions. However, the company may not have the necessary specialist expertise to design and develop the technology required. This represents another form of barrier which will ultimately prevent the exploitation of other technologies.

We can provide an example of such a situation and the solution we have found. The development of robotic technologies to allow the high throughput screening of very large numbers (up to 600,000 per week) of chemical entities for useful biological activities creates a problem of obtaining a sufficient number of chemically diverse compounds to service the screens. This problem was answered by acquiring access to the technology for combinatorial chemistry which is capable of producing thousands of new chemical entities for every one that can be produced by the chemist using conventional methods. However, this created a new challenge because of the considerable call that is now being made on the analytical chemistry laboratory for rapid and high quality analysis of the chemical entities produced using combinatorial chemistry. The existing analytical technologies are no longer adequate to meet this demand, and so new equipment needs to be developed capable of providing an effective analytical service under these changed circumstances. Unless such analytical tools are developed the full benefits of the earlier innovations—robotic screening and combinatorial chemistry—will not be realised and there is a possibility that opportunities for further innovation will be lost.

The problem of the gap between the user and the potential supplier in this context has been solved in Glaxo Wellcome by the development of close links between our analytical chemists and various companies providing the equipment they use. The analytical chemist is able to specify the elements of the new systems that are required but is not in a position to undertake their development. Such an activity would be a diversion from the main function of the laboratory, the development required will often be costly and the pharmaceutical company will usually not be interested in producing and marketing the new system. We have therefore entered into alliances with the producers of existing equipment and collaborated with them to develop modifications to extend the utility of their systems to meet our needs. Existing equipment has been modified and new software has been developed to control it to achieve a robotic system for high throughput mass spectroscopic analysis of chemical samples. Combining the systems development capability of the supplier with prototype evaluation by GW chemists has led to the satisfactory development of a new system which met our requirements, and a new product for the supplier.

In some instances academics have the ability to create new, potentially useful, analytical tools by the application of their research, but have very limited capacity to take their innovation much beyond possible proof of concept or small scale early prototyping. There is, however, often insufficient evidence to interest an instrument company in developing the concept for the market place. Such a situation can be remedied by involving a potential user of the technology in the process. Glaxo Wellcome have experience of this approach. An academic group in a New University had an established reputation in the field of capillary electrochromatography but had insufficient resources to develop their ideas further. GW chemists saw the potential in their work for providing new instrumentation of value to us and so we developed a three way partnership to develop a new system for the separation of small samples for analysis in the mass spectrometer. The third partner is an instrument company with experience in building the components required, and both industrial partners shared the cost of funding a student to continue the development and evaluation work against the specification defined by us. This partnership has now developed the new system and is now proceeding to develop the automation required to drive it.

In both of these examples there was an innovation gap which was able to be closed effectively by developing strong interactive partnerships between the user and the supplier to achieve results that were exploitable by both partners and also, in the latter case brought the academic research through to a new product.

We have recognised the importance of computer technology for many parts of the Company's activities and have made significant investments in creating the infrastructure and expertise in-house to enable us to

make the best possible use of the existing, and emerging, potential of such technology to enhance our own capabilities. Bioinformatics, for example, is of great importance to us in the discovery of new medicines, and plays a key role, in developing our understanding, and capacity to harness, the information being derived from the Human Genome projects. In the development of new medicines information technology is critical to our ability to design our programme of international clinical trials, and for the analysis of the data derived from them. Computer based disease management systems are also becoming significant in the delivery of effective healthcare. Computer technology has become invaluable in the development of the robotic systems we use for screening to discover potential new medicines and for the control of analytical and other costly instruments to obtain maximum benefit from them. Outside the R&D field too computer technology is becoming important. For example it is being increasingly harnessed for the control of production processes and other functions in our manufacturing plants.

(c) *In Process Development*

Any lead compound identified during the research process requires further activities in order to develop an appropriate formulation, and sometimes new delivery devices for it. The route of chemical synthesis will invariably not be suited to the large-scale production of the compound and thus the development of a process for its manufacture is required. Both of these development activities are undertaken within Glaxo Wellcome by GWR&D and the processes transferred later into the manufacturing facilities.

In the development of suitable formulations for a new chemical entity there is scope for the development of both new devices and new methods for formulating the compound in a bioavailable form. GWR&D is prepared to carry out, or sponsor, work to prove the concept when approached by outside bodies offering a technological opportunity provided that the underlying science, when assessed by our scientists, makes sense. We have, for example, also taken the opportunity in some instances to collaborate with academic researchers with relevant new scientific knowledge or novel technologies to develop new approaches and apply them to our own activities. In some cases the approach is made to the company by an academic researcher who is, or has been, one of our collaborators and who is therefore known to our scientists. Provided what is on offer is relevant to our interests and has a clear utility it will be seriously evaluated and, if the concept is proved, could be exploited. There have also been instances, in our experience of academic collaborations, which have led to the development of novel generic technologies that have then gone on to provide the basis of a new spin-out company to exploit them. Our collaboration with the University of Bradford in the field of supercritical fluid technology, which started with a Glaxo supported PhD studentship, is a good example of this. This technology has now been shown to be capable of providing novel methods for the purification of compounds, separation of enantiomers, and also aiding analysis and formulation of the new chemical entities. A company, "Bradford Particle Design," has been formed to exploit this new development.

In the case of development of processes for the large-scale manufacture of a new chemical entity the scope for innovation has often been limited by the Company's available manufacturing plant. Most of this plant is suitable for general purpose use and has some flexibility but may place restraints upon the process development chemists. Thus they would have to change the synthesis to fit the plant rather than change the technology or chemical engineering to produce the best process. The manufacturing plant may thus constitute a barrier to the exploitation of new technology. However, circumstances do arise which require a new technological solution to be found to meet new problems. For example, many of the new chemical entities which are now being progressed for development as new medicines are extremely potent. This is giving rise to develop new means of containment during manufacture in order to protect the work-force and the environment. This will also lead to the development of new plant.

In the past process development has been undertaken by chemists in the R&D function and chemical engineering problems were addressed once the process was transferred from pilot plant to the factory. However, in order to create a more "holistic" approach to process development, chemical engineers have been recruited into GWR&D. This development will, we believe, allow the more easy introduction of new technologies into the manufacturing process. Further, a "New Technology Group" has been established in order to ensure that the company is in a good position to take advantage of relevant novel technology capable of enhancing our process development and manufacturing capabilities. This group is charged with looking towards our investment in new technology and assessing its potential. However, because of financial considerations a new innovation is most likely to be of interest, and hence exploited, if it can be used in respect of a product, and less so if there is no immediate use for it.

New technology is being exploited in GWR&D for process development. The challenge at present is to improve on the efficiency of the development laboratory and allow more rapid definition of the optimum conditions, solvents and other parameters to achieve most effective chemical transformations. New methods and equipment are being developed to allow many small-scale reactions to be carried out simultaneously under various conditions and analyse the outcomes. This is again being achieved by collaborating closely with equipment makers and harnessing their expertise and that of the GWR&D scientists. New technologies are also being exploited in order to mimic plant scale reactions, to develop a better understanding of behaviour of the chemical reactions during scale-up and to resolve chemical engineering issues and problems before transferring the process into the plant.

(d) *In Manufacturing*

Once a process has been defined by Process Development Chemists and is established in a factory it may be difficult to introduce new technologies later to improve the process or the product. Any change to the process must be justified on business grounds and be shown to have clear benefits. In the present economic climate considerable pressures are being put on prices of pharmaceutical products by healthcare providers. Furthermore changes made to a process may also result in changes to the chemical or physical form of the compound which are unpredictable and could affect its biological activity. Quality of product and patient safety must obviously not be compromised by any change. Considerations such as these may constrain the potential to exploit new technologies which would have to deliver real quality and cost benefits before they would be implemented.

A further significant barrier to innovation lies in the highly regulated nature of the industry which may again constrain the potential to improve process efficiency or even product quality. Any introduction of a change to the established process would require the submission of a supplementary NDA to the regulatory authorities. It is frequently easier and, on balance, more cost effective to maintain the status quo because this regulatory hurdle, in terms of the extent of qualifying data and the time taken for approval, is too immense.

There is, however, scope for the introduction of new technologies into the manufacturing area. The exploitation of improved containment technologies has already been referred to. There are also other areas in which new technology may be exploited to provide solutions. For example, IT systems are being developed within the Glaxo Wellcome organisation to allow "virtual technology transfer" (ie databases and process information) between groups in Process Development and in Production sites. Such systems are being extended to cover other areas such as engineering, plant and equipment (in collaboration with outside specialists) and ultimately to procurement and suppliers. We have now created a group of some 200 people, drawn from a range of scientific technological disciplines, who are specifically charged with the task of exploring better ways of doing things in the manufacturing area, identifying relevant new technologies and examining ways in which they may be exploited. To ensure that this group is able to make the best possible contribution it is internationally based and it now provides a very significant focus for the Company on manufacturing technology.

Another example is the new technology being used to develop Programmable Electronic Systems (PESs) for control of aspects and processes which impact on safety of the medicines, and also other Health and Safety. Currently hardware based protective systems are used in most parts of the process industry and these can be associated with high costs due to factors ranging from the provision of a number of levels of independent hardware to provide a high degree of confidence, to the need for maintenance personnel required for the regular testing of systems again to ensure confidence in the system. The exploitation of Programmable Safety Related Systems may result in significant benefits in terms of both costs and also manufacturing flexibility whilst providing for the requirements for safety and reliability. However the process industry is taking a cautious approach to the use of this new technology which could lead to a failure to fully exploit it to gain competitive advantage. A major issue which must be addressed in connection with the implementation of PESs is their assessment and validation and the establishment of a system for their accreditation. This can only be achieved by pan-industry involvement and to this end the DTI, EPSRC and industry have established the "FRESCO" initiative. This is funded under the Safety Critical Systems Programme which is part of the five year Advanced Technology Programme of collaborative research. Glaxo Wellcome participates in this project as a member of the FRESCO Interest Group which draw on the experience of a wide range of companies in the process industry.

4. Government Initiatives to Stimulate Innovation

Both Glaxo and the Wellcome Foundation, and now Glaxo Wellcome, have experience of a number of Government or Research Council initiatives designed to encourage academic-industry collaboration, and thus the transfer of knowledge and technology. We have long been active supporters of the collaborative PhD studentship concept which was originally introduced as the CASE scheme by the old SERC. We have found these awards to be of considerable value. Not only do they provide training for the student within the industrial environment, but they also provide an opportunity for the students' academic supervisors to collaborate with industrial scientists. We have therefore developed our own, fully funded, co-operative PhD studentship scheme and this is used in the case of 95 of the 278 PhD students we currently support. The other 183 are supported jointly with the Research Councils. A number of our collaborative research projects and programmes had their origins in co-operative studentships, which have therefore played an important part in building bridges between us and our academic colleagues and the development of long term relationships between company and academic scientists.

Glaxo has been a participant in the LINK scheme since its inception. We were partners with the Biochemistry Department of the Univerisity of Oxford and British Biotechnology in the first LINK programme. We have now been involved in over 20 different LINK projects and programmes which have varied from small partnerships to programmes involving large numbers of other companies and academic departments. We have found participation in these projects to be an effective means of developing and sharing new scientific knowledge, and for transferring technology and research tools between the partners. However, to be really effective participation in the programme must be active and there must be a company scientist

with responsibility for our scientific contribution and to serve as a conduit between the company and the other partners. The other essential feature of an effective LINK programme is the provision of a dedicated project manager whose task is to act as the liaison between the partners to ensure flow of information and technologies. Those programmes which have lacked or had an ineffective manager have, in our experience, been less successful. LINK projects we have been involved in have resulted in a number of useful outcomes including the development of molecular probes for use as research tools, novel instrumentation, software for molecular modelling, defined cell lines for expressing drug metabolising enzymes, and the development of new technologies for synthesis of chemicals. As the LINK project provides underpinning research, often of a generic nature, rather than marketable products, new information generated as a result of the research undertaken is usually published and thus has potential benefits to the wider science base rather than being exploited by a single company.

Currently, most of our LINK projects involve the research departments of the Company, although there is now increasing participation by groups within the process development activities in GWR&D and in the manufacturing areas. As with our other academic collaborations, we find it essential for greatest benefit to be derived that the subject matter of the project is relevant to the interests and strategic objectives of the company and that the personnel engaged in the collaboration have a real commitment to it.

We have a growing involvement in European Union Initiatives for collaborative research with research projects supported under Framework IV and technology collaborations through schemes such as "LIFE" which supports Community environmental policy. An example of the latter, in which Glaxo Wellcome manufacturing groups are currently involved as partners, is the programme seeking solutions to the environmental problem of volatile organic compounds (VOCs) which are widely used in industrial processes during which there may be escape into the environment. Current technology is used to destroy such organic vapours and reduce their release into the environment to presently acceptable low levels. However, such technology does not provide energy and cost efficient solutions to the problem of achieving very low levels of contamination. This project is therefore aimed at developing and applying new microwave technologies to provide cost efficient means of destruction of these (VOCs). Such technology is available through one of the partners, but requires "proof of concept" investigations before its real utility can be defined; it is these studies that the EU "LIFE" funding is supporting. As this is a pan-industry problem the solutions sought are likely to be generic rather than directed at specific areas. It represents a relatively small problem for our Company but is a significant one for industrial activities as a whole and this is well suited to multipartner involvement such as is achieved through the EU scheme. If the concept is successful then Glaxo Wellcome will get access to the technology for its own application at reasonable costs. Thus this project is a good example of a scheme which could lead to exploitation of technology that may otherwise not be used.

Another example of collaborative arrangements of a pan-industry nature involving Glaxo Wellcome's manufacturing groups which could make new technology available for exploitation, is the FRESCO initiative mentioned above. This collaboration has lead on to a further initiative involving a number of European process industry companies in order to bring about a faster development of professional design practices relating to the use of PESs and to accumulate a wider range of practical field experience of the technologies. Again this development, which is supported by Glaxo Wellcome is being undertaken on a partnership basis with funding through the EU ESPRIT scheme.

5. Effectiveness of Initiatives to Encourage Collaboration

In our experience the schemes mentioned above, together with collaborative support schemes operated by companies such as ours, have been effective in bringing about closer relationships between industrial and academic science and technology. The last decade has seen a marked, and welcome, change in the attitude of many in academic scientific research towards industrial science. There is now a greater willingness by many in academia to work on problems of relevance faced by industry. For companies such as Glaxo Wellcome strong links with researchers in universities is crucial for our future success in discovering new medicines aimed at the cure or serious modification of human diseases.

Schemes such as LINK have also been effective in achieving industrial synergies by bringing partners from different sectors together in collaborative research projects. They are also to be encouraged as a means of addressing generic or pan-industry problems to discover technological solutions. In some instances the scheme has created the "critical mass of interest" to achieve investment in the research by a number of partners willing to invest some funds in the work but unwilling to take total responsibility for it. Thus they are now seen as an effective means of levering value from the company investment. An example of this can be seen in the LINK project with the University of Dundee aimed at developing cell lines containing human drug metabolising enzymes which will form tools for use in Biometabolism studies. Such cells will provide a more precise form of assay than currently exists. Nine pharmaceutical companies joined this partnership resulting in a total investment in the project of over £1 million. No single company would have the commitment or resource to fund this project independently and so LINK has provided a vehicle to create the critical mass needed for the project.

LINK has also provided a mechanism allowing companies from the SME sector to become involved as collaborators with large multinational organisations and academic centres of excellence. Glaxo Wellcome has been involved with small chemical companies as part of the "Asymmetric synthesis" programme which has

not only allowed the smaller company to develop links with Glaxo Wellcome, the research has opened up new avenues of research for them.

The LIFE, FRESCO and ESPRIT initiatives of the UK Government and EU are also of significant value in that they create groupings of different Companies with shared interests in a new technology for the purpose of defining and evaluating new developments. A critical mass of interested collaborators is thus achieved and the result is more likely to be successful implementation, and realisation of the benefits of new technology than if companies were to act in isolation. Thus collaborative schemes such as these have value in the real synergies that they can achieve.

There are, however, other recent schemes which we believe to have been unhelpful. An example of such a scheme was the introduction of the GR funding element devised by HEFCE to reward academic departments for developing collaborative research links with industry. For pharmaceutical companies this proved to be counter-productive because of the conditions regarding intellectual property which were imposed on the awards. This resulted in most of the academic groups working with us not qualifying for the GR element of funding. We would not have supported the work had the academic group insisted on owning any arising intellectual property (a condition for receiving GR funding). Although GR represented a relatively small proportion of HEFCE research funding, it did give rise to acrimony which could have been avoided had the HEFCE officials consulted the industry during their development of the scheme. Similarly, we believe that the various Government schemes introduced recently to encourage matching industrial funds to support academic infrastructure have been less than helpful. Invariably these schemes have been introduced without any prior consultation with industry, and we have found that when we have declined invitations to partner academic collaborators in applications for such funds there has been some souring of relations between us. There must also be a realisation on the part of Government departments designing such schemes that there are limits to the amount of funding available in industry for such support.

Difficulties with UK Government and EU schemes designed to encourage collaborative research, technology transfer and exploitation of new technology lie in the bureaucratic nature of the arrangements. The rules of many schemes, particularly those defining their scope, are often not clearly laid out. The application forms to be completed are sometimes complicated and time consuming. The time intervals allowed between the call for applications and the closing date for their submission may be unrealistically short, particularly as there may well be budgetary consideration for the potential company partners to take into account. Timescales must therefore be realistic if companies are to make budgetary provision to allow involvement in these initiatives. The decision times, in contrast, are often protracted with the risk that the momentum and enthusiasm for the project on the part of the potential partners will be lost. The recent "Technology Foresight Challenge" was a good example of some of these problems. Glaxo Wellcome process development chemists were partners with colleagues from 10 other companies in a major application for funding under this scheme to support a study of the way chemical reactions behave when processes are scaled up. This project, which is of a generic nature and of interest to a number of potential users in industry, was to centre around work to be carried out at Heriot Watt University. After a protracted selection process we learned that this was not one of the programmes to be supported by the Challenge fund. The partners are therefore now faced with the prospect of having to find funding from other sources, possibly a Research Council, and a considerable delay has been introduced into their plans. A further problem that may arise as a result of the slow decision making process lies in the speed at which science and technology is moving. This makes it important to establish procedures which ensure that momentum is maintained amongst the partners and that the project proposal is not overtaken by events elsewhere.

Finally, there are now many different Government and EU initiatives to support multipartner collaborative research and exploitation of technology. It is becoming increasingly difficult to keep abreast of these schemes and to understand them and their relevance to company activities. Thus more effort is needed by originators of these schemes to ensure greater awareness and clarity of what schemes are available which may be of value to companies.

6. Other possible Support Systems to ensure Maximum Advantage of Innovative Ideas

(a) There are a number of potential technological advances made during the course of what is regarded as blue sky research in UK HEIs which may be adaptable to other uses which may be of commercial value. Similarly developments resulting from research in one area of science and technology designed to meet a particular need, may have application in areas beyond those for which they were developed. These type of circumstances should be recognised as providing potential for the wider exploitation of technologies within different sectors of industry or commerce, including the SME sector. The problem lies in bridging the gap between the academic, or other, originator and the potential industrial/commercial developer. An approach similar to the "dual use" concept which has been developed in the context of technology developed by the defence research establishments and defence industries could be adopted to provide this bridge. Ways need to be created of increasing awareness within a wide range of industry or commercial sectors of technologies being developed elsewhere and encouraging new, or wider, uses for them. Organisations such as the Centre of Exploitation of Science and Technology (CEST) could have a clear role to play in the dissemination of awareness of such opportunities.

Information Technology, and in particular the World Wide Web, has considerable potential for bridging the gap between originators of new concepts and information and the potential users. This could be used effectively to create "catalogues" of available skills and technologies and for the transfer of information. We therefore welcome the creation of initiatives such as the Network for the Exploitation of Science and Technology (NEST). This aims to use Web-based technology for the creation of "virtual" centres and partnerships to bring together complementary skills and to create awareness of developments in science and technology.

(b) It is frequently the case that concepts originating within academic laboratories are offered to potential industrial developers who decide not to become involved in further development and exploitation of the concept. There are a number of reasons for such failure but a common one, in our experience, is the premature nature of the information and data supporting the concept. Academic groups often do not have the resources, in terms of infrastructure and finance, to allow them to progress their invention to the point of proving the concept and defining its limits of utility. Similarly companies are not prepared to make the necessary investment in the absence of such information. Thus it is suggested that the concept of the Technology Incubator needs to be developed and expanded in the UK in order to provide the resources needed for this essential step. We therefore welcome the identification of this need by a number of the Technology Foresight Panels and the proposals and plans that are now emerging to develop such facilities adjacent to university laboratories. A clear distinction must, however, be made between the "Technology Incubator" and the "Start-up Company" which we see as being distinct entities serving different purposes. The purpose of the Incubator is to provide the resources needed to prove the concept and define its potential. The outcome may be a decision to license the technology to an existing company to exploit it, or to create a new company, outside the incubator, for this purpose. Alternatively the activities undertaken may show that the concept is flawed and further costly development avoided. Such Technology Incubator developments require space, facilities, equipment and financial support and could be developed as partnerships between the Higher Education Institutes, venture funders, TECs, local or central government departments and industrial or commercial companies. Model developments, such as the Massachusetts Biotechnology Research Institute in Boston, USA, are worthy of examination. This organisation brings together local and State government, regional HEIs and venture funders to provide a facility in which individuals may try out their ideas for new products/businesses. The time available for this is strictly limited to two years after which the project is abandoned or measures taken to exploit it. This Institute has been successful in enabling a number of its clients to launch their own start-up companies in the region.

(c) During the late 1980s and early 1990s there was a reluctance of Government to provide support for what was deemed to be "near market" research. There was moreover a very narrow view taken about what collaborative research involving industry was to be funded by Research Councils, or through initiatives such as LINK. This created a problem of funding for the development of new technology with potential commercial utility if it was perceived by government departments as too "near to market", but yet by industrial concerns as still lacking in terms of "proof of concept". Government schemes should in future avoid this danger, be more relaxed in the definition of "near market" and possibly develop schemes under which successful exploitation of technology leads to some pay back to the public purse, possibly through taking an equity position in such projects in return for financial support.

7. The Influence of Technology Foresight

Some Glaxo staff, mainly drawn from the Research areas, were involved in the general Technology Foresight consultation process, and Dr Barry Ross, Director of Research Strategy and Alliances was vice-Chairman of the Health and Life Sciences panel. The Technology Foresight Programme output has, however, had little impact on most areas of the Company outside the immediate Research areas and in these cases attention has been confined to the reports of the most relevant panels—ie Chemicals and Health and Life Sciences. The Technology Foresight exercise has therefore not penetrated very far into this Company and we believe this to be a not unusual situation within the industry and our suppliers.

Glaxo Wellcome was a partner in six submissions for project support from the Technology Foresight Challenge fund. Of these only one was successful and this project, in the field of combinatorial chemistry, was under consideration for support by us before the Challenge was announced. We are however participating in a new initiative created by the Medical Research Council to address the problems of ageing which is one of the priority areas highlighted by the TF exercise. It is felt within the manufacturing parts of the company that those areas most likely to receive support as a result of the Technology Foresight initiative, involving academia, are those at the "leading edge" of science and that there is less desire to fund the sort of solid technology development required by industry.

To some extent the response to the Technology Foresight programme has been conditioned by the fact that Glaxo Wellcome has for a long time maintained its own technology awareness mechanisms. These are strongest within the R&D organisations, where they often operate at the level of individual research scientists. There was therefore little in either of the two most relevant reports that was not already known to us. Technology Liaison Groups, made up of technical experts, also operate at an international level within the Glaxo Wellcome manufacturing functions. These have a remit to seek out new technologies which have potential costs, efficiency, safety or environmental benefits and assess their value to the Company.

8. The maintenance of technological skills

An important factor which will determine the future ability of UK companies to harness and exploit new technologies and be innovative is the skills base of the workforce. It is important therefore that individuals emerging from science, engineering and technological departments of Higher Education Institutions (HEIs) are provided with a good level of knowledge of their fields and the skills needed to practice their discipline. HEIs should also ensure that their undergraduates and postgraduates are encouraged to develop the transferable skills required for the world of work and that the entrepreneurial spirit is fostered within them. The rapid change that has been witnessed in most areas of science and technology over the last decade has set a pattern which is likely to continue well into the future. Thus to be in a position to be innovative and exploit new scientific knowledge and technological developments effectively it is important that the level of knowledge and skill in individuals is maintained at a high level throughout their working life. Failure to create an environment in which lifelong learning is an accepted norm will create a significant barrier to innovation, and so jeopardise the UK's competitive position. Thus to ensure that this barrier does not exist it is necessary to encourage companies to provide continual training and reskilling for their staff at all levels, and for the HEIs to play their part in the provision of appropriate courses in close collaboration with local industry and commerce.

Glaxo Wellcome recognises that high quality teaching of science and technology in our schools and universities is of paramount importance. This is vital to ensure that the nation has the skilled and knowledgeable workforce required to service industrial and commercial activities, which are increasingly becoming dependent on the application of advances in science and technology. We have therefore major programmes of support for schools, from primary to sixth form, and universities to encourage this.

Glaxo Wellcome, itself, is committed to being a learning organisation in which opportunities are given for all members of staff to continue their development and acquire new knowledge and skill. We therefore are developing resources such as open learning facilities on our sites and using IT tools to create a "knowledge network" to allow sharing of ideas and information and spreading new knowledge throughout all parts of the organisation. Courses are also provided by the company which are designed to develop the various competencies of our staff and their career progressions. These courses, which are funded by Glaxo Wellcome, may be delivered internally through the training departments, and often involve outside trainers, or may be arranged in collaboration with local HEIs or Business Schools. Appropriate staff are also encouraged and supported to take external courses leading to new qualifications ranging from Diplomas to MBAs and Doctorates. The total Glaxo Wellcome expenditure on staff training in the UK is in excess of £16 million per annum.

9. The Knowledge Gap as a Barrier to Exploitation of Technology

The scope of new technology may now be very broad and have potential application across a range of different industrial, or indeed academic sectors. The division of science and technology into tidy pigeon holes is no longer sensible if maximum use, and thus benefit, is to realised. For greatest benefit to be derived it is becoming increasingly important to look across disciplinary boundaries and often into areas of science, engineering and technology which are quite far removed from the organisation's, or individuals' own interests and activities. However, the organisation of many institutions, industrial or academic, is still much along the subject discipline lines. This creates a "knowledge gap" which impairs the acceptance of new technologies and the appreciation of the full value of new knowledge and so can present a real barrier to innovation and exploitation. Some examples of this "knowledge gap", drawn from our own experience, have been provided above.

In the number of contexts there is a need for a new solution to problems that arise in businesses because of changing circumstances which may include pressures from competitors. Those needing to bring about the change usually know what they require to solve the problem but do not have sufficient breadth of knowledge or expertise to be able to provide the solution. This is inevitable and probably will always be the case. There are others who may be unaware of the problem but who do have the skill and experience to provide the solution. There is, however, a gap between them which, to achieve progress must be closed. In our experience this gap can be closed through creating alliances with other organisations in our various supply chains. These organisations, more usually seen as providers of equipment, resources or services are now seen instead as partners actively working to achieve synergies to provide innovative solutions. For the user the obvious benefit is the ability to move forward but to the other partner(s) there will be new products for their market place and thus there is benefit for both. We see this type of alliance as a valuable means of benefiting our business and, as mentioned above, have developed such relationships with contractors, suppliers and consultants to create innovative development solutions and to exploit them to achieve our own goals.

In order to promote such alliances it is important that the partners clearly understand each others position. Thus the "User" partner must be able to specify clearly the need, and the solution must be within the competencies of the "Supplier" partner. It is essential that they are able to work together in an open fashion, sharing ideas and developing new concepts throughout the process of building, evaluating and modifying the desired product. An atmosphere of secrecy between collaborators is counter-productive to this process. Furthermore there is no reason why, if a particular development needs it, collaborations should not be established involving a number of partners each having something to offer the project. These may include

other organisations from the same sector who may be more usually seen as competitors. This will become possible once it is clearly realised that the competitive advantage to be gained from new technology may often not lie in its development *per se* but in how it is exploited by the individual companies for their own use. This is one of the valuable lessons which has been learnt from collaborative schemes such as LINK.

As technology becomes complex, and instrumentation required calls for more than one discipline, the knowledge gap will become a block to progress unless mechanisms are found to bridge the gap by engaging specialists from a number of different areas with a commitment to co-operate and very often these specialists will not all be found in the same organisation. Therefore in the future companies must be prepared to recognise the core competencies and technologies of their suppliers as having value for themselves and developing mechanisms to exploit them to solve problems across a range of their activities. They also, however, need to have in-house groups to maintain awareness of technological developments and their own technology acquisition policies. It is also helpful if these processes are transparent so that potential technology collaborators have a route of entry into the company with their technology and understand the evaluation and decision making process that will be employed. Where there is confusion in these respects the chances of failure to make contact is high with the consequent potential loss of opportunity to exploit technological advances. The development of Supply Chain management processes would help in this context and this would lend itself to a collaborative project approach with partners from different sectors coming together to share experiences to define the issues and identify potential solutions.

There is considerable potential in the development of new schemes and initiatives designed to engineer the closing of this knowledge gap and so bring about the more effective exploitation of innovative technology. Dissemination of the knowledge and insights of those who have experience of this problem, and the development of best practice models, will clearly be of value. We welcome the recent initiatives being developed by the Research Councils to promote better understanding of manufacturing processes and industry issues. These include the Engineering and Physical Sciences Research Council's "Innovative Manufacturing" and "Clean Technology" programmes, and the Economic and Social Sciences Research Council "Innovation" programme. Similarly the EU "Sustained Technology" (SUSTECH) programme is likely to assist in developing practices in this field.

Memorandum by the Institute of Physics

Introduction

1. The Institute of Physics is the learned society and professional body representing qualified physicists in the UK and Ireland. With a membership of more than 21,000 individuals in January 1997, around 30 per cent are employed in industry and the public sector, many of these in small and medium sized enterprises.

2. The Institute also operates two company membership programmes. The 24 members of the Corporate Affiliate scheme are the major employers of science and engineering graduates in the UK. Members of the Institute's SME Club represent the other extreme of company size, a number of these being sole-traders.

3. During 1994, with support from the DTI (Innovation Unit), the Institute commissioned a telephone-based survey of small physics-based companies in the UK[8]. The objective was to identify the major issues affecting their development and growth, and the degree to which existing service provision meets their current and future needs. One hundred and fifty organisations were questioned both from within and outside Institute membership, making this the largest systematic survey of this specialised sector in recent years.

4. In January 1996 the Institute published a complimentary report for small and medium-sized enterprises on the implications for them of the 1994–95 Technology Foresight Programme[9]. Following distribution of this document a detailed telephone survey of 40 recipients was undertaken, both to establish the effectiveness of the report and to explore the attitudes of readers to a range of other topics relating the business environment for small firms.

5. Also in 1996, The Institute commissioned the Science Policy Research Unit at the University of Sussex (SPRU) to undertake a study of the links between university physics and industry[10]. Contributory funding was provided both by the DTI (Technology and Innovation Policy Division) and the Particle Physics and Astronomy Research Council (PPARC). Draft copies of this report are currently available.

6. This submission is based on the results of the formal surveys referred to above, together with the views of our wider membership.

7. The submission is ordered according to the questions posed by the Committee in its request for evidence.

[8]Small physics-based companies in the UK. Alan Weaver Associates, August 1994.
[9]Technology Foresight—The implications for small and medium-sized enterprises. The Institute of Physics, January 1996.
[10]The links between university physics and industry. Keith Sequeira and Ben Martin. To be published.

SUBMISSION

What is the current state of innovation in the United Kingdom?

8. "Innovation" is defined by the DTI as "the successful exploitation of new ideas". These new ideas may be related to management of human resources, or to administration of business processes etc, just as they may derive from advances in the technology for materials, processes or products. Discussions with our contacts suggest that technological progress continues to be a great strength of the UK's scientific and engineering community. Our weakness continues to be in integrating those technical advances with all the other factors which will lead to truly profitable innovation.

How successful have the DTI and other Government Departments been with their range of initiatives designed to stimulate innovation?

9. Lack of awareness of Government initiatives and confusion about what is available appear to be continuing problems. Those of our members who are well-informed about what initiatives exist, and are motivated to apply, appear generally to be satisfied with what is on offer. Conversely, there are those organisations which are either unaware what is available or claim that to become involved in schemes is too time-consuming and bureaucratic. It would be interesting to monitor if awareness of and participation in support schemes is a measure of growth potential in firms.

How effective in terms of product or process innovation and other exploitable outcomes are initiatives which encourage collaboration between industry and academia?

10. In some scientific disciplines, of which chemistry is the prime example, the path from academic research to industrial exploitation is both linear and clear. Schemes designed to encourage collaboration between industry and academia naturally aim to monitor this progression to exploitation and seek to reward those who can demonstrate success in this area.

11. The study undertaken by SPRU for this Institute clearly shows that, for physics, the model is far more complex. Advances in physics do indeed lead to wealth creation, the discovery of the transistor principle leading to the development of microelectronics and the entire IT industry, for example, but the path from discovery to exploitation in physics is frequently tortuous and lengthy. Selection or reward criteria for some recent initiatives do not always recognise these different routes to technical innovation, disadvantaging those whose work is furthest from the market.

12. Government initiatives to encourage collaboration favour companies which already have good contacts with academics working in their field of interest, because of their shared backround knowledge and the often short timescales set for bid submission. Encouragement to bring new firms into collaboration with academia is needed, especially for those smaller organisations where the resource involved both in preparing proposals and in building up effective working relationships with academia must be balanced against the immediate requirements of running the business.

13. Over the past few decades there has been increased competition for academic posts. The Research Assessment Exercise measures excellence by academic performance, fuelling competition between individuals, departments and universities in a way which has a profound influence on the values of those involved. Such an environment contrasts sharply with that encountered in industry where the general objective of innovation is to improve company profitability. Though government initiatives may seek to promote collaboration between industry and academia, this will never be truly effective, with all partners really satisfied with the outcome, whilst the driving forces for the two groups remain so fundamentally different.

14. Innovation can take place anywhere, not only in the universities and via university-industry collaboration. Support and encouragement for innovation in companies must also be developed.

Does financing need to be improved for technology-based small firms during their crucial start-up and early development phases?

15. Many of the companies we surveyed during 1994 have an urgent need for external finance and for different reasons. New micro-businesses (employing less than 10 staff) need access to funding for product development. Established, more successful companies (employing between 20 and 40 people) need funding for organisational growth and for market expansion. Survey respondents were preoccupied with obtaining finance, reporting generally poor experiences with existing sources of funding, apparently exacerbated by the highly technical nature of their product/service.

16. The problem lies not just with funding providers, but also with the businesses themselves who frequently do not understand the priorities and requirements of their contacts from the financial world. Technical strength cannot compensate for a badly run business and technical entrepreneurs seem slow to appreciate the non-technical skills their business needs to thrive. This is naturally a considerable problem for the smaller organisation which often cannot afford to employ the business specialist they need. Our members

have found that, for high-tech businesses at least, Business Links are not currently filling this gap, though clearly they have the potential so to do.

What other support systems could be introduced to ensure that the maximum advantage is taken of innovative ideas that originate with individuals or, for example, in academia?

17. The return of a public-funded organisation with responsibility for monitoring innovative ideas and seeking routes to exploitation has many attractions.

18. Small companies need help and assistance to access new markets and to exploit fully the opportunities in existing markets. A large number of respondents to our 1996 survey were unable to describe their company's strategies for accessing markets. Many of the companies were over-focused on the features of their own products and failed to recognise the needs of potential customers in the market. Technology transfer initiatives to move innovative ideas from universities to industry could usefully be extended to move industrial products and processes into new markets.

Is there institutional inertia towards the funding of technology-based small companies? If so, to what extent may this be due to financiers' unfamiliarity with science and technology concepts and what should be done to address this?

19. Communication is a two-way process. Financiers do not need to be familiar with science and technology concepts, but they need to understand the inherent risks and opportunities of developing high-tech materials, products or services. Conversely, scientific entrepreneurs must have a realistic view of what they can achieve and to be able to convey this to backers, customers and their staff. They must understand that technical expertise is not a substitute for effective management. All measures to promote dialogue between the two groups of people are to be encouraged.

The Committee recommended tax credits for research and development in our previous enquiry. Would this still be an effective way of fostering innovation and how should they be introduced to ensure that they are roughly cost-neutral?

20. We believe that tax credits for research and development would be an effective way of fostering innovation. They should not be financed in a way which penalises companies for success.

How has the Technology Foresight Exercise influenced the availability of development funds for innovative ideas that were not given short-term high priority status?

21. We have no data on this point. It would be regrettable, however, if the essentially instantaneous view of technology presented by Foresight were to have a major impact on development funds for what is a rapidly changing technological environment.

Has the tax relief introduced in 1992–93 for individuals' expenditure on vocational training had any impact on the status of continuing professional development, in particular for employees in small firms?

22. We have no data on this point.

14 January 1997

Letter from Lord Kennet

I am writing this in the form of a letter because I am not sure if it can count as evidence, but please circulate it to the members of the committee if you think fit.

I have one domestic point. With "customer"-led science, do we not necessarily miss out on what the customer—whether department or commercial concern—hasn't a clue about? The Japanese government is now itself to fund more blue-sky research because industry isn't, and can't be geared to, doing it.

My main observation is about international comparisons. The questions 1-9 as set out in the invitation to submit evidence all refer to questions which exist, and are assumed to be answerable, within the frontiers of this country. But to the extent that we fear we are not as good as other countries in overcoming the "innovation-exploitation barrier", it would be useful for us to inquire what is done about it by the countries which are best at it. If the wheel has been invented elsewhere, we may not need to reinvent it.

Which countries, and in which fields? International studies into those questions are now numerous and serious. Besides the best authorities in this country who will be easy to identify, it might be useful to inquire of an international source of wisdom. One such is the new Institute for Prospective Technological Studies in Seville and/or, of course, its parent authority, Directorate General XII of the European Commission.

Outside the European Union Japan is always the centre of interest, though there is a growing, but still minority, opinion (I think) that by now we may have as much to teach them as they have to teach us. A good source on this is the UK-Japan High Technology Industry Forum, chief executive Louis Turner, 30 Fortnam Road, London N19 3NR.

There must of course now be comparative studies of what they do in countries like Taiwan, Singapore and Malaysia. For this it might be worthwhile making separate contact with the relevant sections of DTI: separate, that is, from the contact you will obviously be making on the main intra-UK inquiry.

16 January 1997

Memorandum by Innovation and Growth Unit, NatWest UK

Introduction

This memorandum has been prepared by the Innovation and Growth Unit, NatWest UK drawing mainly on extensive experience in the technology-based business sector over a number of years (the Innovation and Growth Unit was established in 1989). Some consultation with representatives of other Units within the Bank has taken place, but, given the short deadline, the consultative process has necessarily been of a limited extent.

The Select Committee enquiry into the "Innovation—Exploitation Barrier" follows the publication of a series of recent and on-going studies which have all highlighted the particular issues effecting small technology-based firms. These include:

— "The Financing of Technology-Based Small Firms"—The Bank of England, October 1996.

— "Growing Success: helping companies to generate wealth and create jobs through business incubation"—The Enterprise Panel 1996.

— "The Barriers to Start Up and Growth of Technology Based SMEs:" CBI study to be published shortly. The Head of the Innovation and Growth Unit has been actively involved with the Working Party throughout.

On the issue of innovation in general, since 1990 the NatWest UK Innovation and Growth Unit and the CBI have undertaken an annual "Innovation Trends Survey". The CBI/Natwest Innovation Trends Survey as it is known has established itself as a widely accepted benchmarking survey covering the perceptions of a wide range of UK companies towards innovation and the level of company resources/annual expenditure committed to support innovation. (the 1997 Survey will be sent to 10,000 companies of all sizes in late January 1997).

To support the submission we attach copies of the following documents:

— The Financing of Technology-Based Small Firms"—Bank of England (October 1996).

— "CBI/NatWest Innovation Trends Survey"—Issue 7 1996

— Issues 14, 15 and Omnibus Edition of *Innovation Business*

— Article on Innovation by D S Matthews

— Parliamentary Brief article on "Growth Business—Turning Promise Into Reality

— Innovation Business "Briefing 1 and 2".

Q1. What is the current state of innovation in the United Kingdom?

Definition:—Innovation is the profitable exploitation of new technologies, products, processes or services.

Innovation is more than just research and development and includes investment in market research, training and across many other areas of companies' activities. Innovation is also not related solely to the development of wholly new products or processes, but can refer to incremental innovation or the application of new technologies, products or processes across sectors. Quantifying or measuring innovation is not an exact science, primarily because it is a continuous process, rather than a series of discrete events. As it consists of a diverse range of inputs (eg R&D expenditure) and yields outputs (eg sales), there is no clear audit trail. Given this broad definition of innovation it is not possible to provide a single hard and fast indicator of innovative performance, and it is necessary to consider a number of different inputs/outputs moreover, to make the data meaningful, measurements must be comparative rather than absolute.

For a number of years, reports and studies have emphasised that innovation is the lifeblood of economic progress and competitiveness, and that technology based small firms are of major importance to the future growth of the economy. Innovation has been identified as central to the spirit of enterprise as all businesses operating in competitive markets must produce innovative products through innovative processes to survive and maintain, or increase, their market shares or move to exploit new market opportunities. The value of innovation as a critical factor in the development of national economies is demonstrated by the economic performance of our competitors in the USA, Japan, and the newly industrialised countries of the Pacific Rim.

The first major initiative by the Government to promote innovation came with the launch of the "Innovation—The Best Practice" by the DTI in 1993, based on work done during 1992. This determined that:—

— One in ten countries were truly innovative on a world-class scale.

— a further three to ten showed good performance in many areas.

— another five to ten evidenced good performance in some aspects of the innovation process.

We understand that the CBI and the DTI Innovation Unit intend to undertake a follow up study in late 1997, with the prime objective of identifying if there has been an overall improvement in the number of UK companies which could be classed as truly innovative on a world-class scale. However the 1993 Report referred to above was some three years after NatWest launched its Technology Unit, re-named Innovation and Growth Unit in 1995. In our view, therefore, we believe it is reasonable to compare statistics from 1991–92 with those of 1995–96 to assess the present state of innovation. This comparison has been carried out on a number of factors/indicators:

1. R&D Performance

The R&D Scoreboard is the main indicator of the health of UK research and development. The results of the 1996 Scoreboard were disappointing, with the lowest rise in R&D investment for five years (+4 per cent), and an increase in the investment gap with overseas competitors. Whilst it is not possible to compare absolute figures with 1991 (different sample size) it is possible to look at R&D intensity (ie ratio of sales to R&D expenditure). This indicates that:

— in the 1996 Scoreboard, the overall sales: R&D ratio was 1.7 per cent (bottom of the table), and that of the top 18 firms was 2.5 per cent. The comparable figures for our major competitors were Japan (4.9 per cent), USA (4.2 per cent), Germany (4.3 per cent), France (4.0 per cent), Italy (2.8 per cent).

— by comparison with 1991, the UK has not improved its position vis-à-vis its main competitors. Overall, R&D intensity increased marginally over the period, but in most other countries there was a larger improvement.

— in sector terms, UK is placed poorly in most sectors, and only pharmaceuticals is comparable in R&D intensity to the international average. However, in all major industrial sectors (ie chemicals, pharmaceuticals, healthcare, engineering, electronics) UK intensity has fallen since 1991 to a greater extent than our competitors.

It is also significant that an increasing proportion of R&D is being financed by overseas organisations who will ultimately benefit from the research results. In 1991 11.8 per cent of UK's R&D expenditure came from overseas; in 1994 the figure was 12.7 per cent. By comparison, the total of overseas investment in Japan has remained constant at 0.1 per cent, Germany's has fallen from 1.9 per cent in 1991 to 1.8 per cent in 1995 (OECD figures).

However, R&D investment is not necessarily a direct indicator of best practice in innovation. R&D investment is only one input, albeit essential, to the whole innovation process.

2. CBI/NatWest Innovation Trends Survey

The *CBI/NatWest Innovation Trends Survey* was instigated in 1989 and measures a wide range of innovation inputs and outputs. The 1996 survey reports on 1995 activities. Since 1991:

— overall expenditure on innovation by manufacturers has increased from 4.3 per cent of turnover to 6.3 per cent. (Expenditure includes capital expenditure, training, process/product R&D). However, 1991 figures were exceptionally low, due to recessionary pressures, and in general the figures are recognised as following the pattern of the UK business cycle. If this is the case innovation expenditure cannot be regarded as increasing in real terms. Rather it is a direct result of overall economic health, and as such will be reduced under difficult trading conditions, when in fact it should be regarded as a precursor or prerequisite of improving business performance.

— Expectations for future spend in the 1997 CBI/NatWest Innovation Trends Survey are that the 1996 figures will be marginally higher for R&D and capital expenditure, though new product development spend is expected to be fairly steady, with greater emphasis on minor changes and incremental improvements to existing products rather than brand new product development.

The proposed CBI/DTI follow up "Innovation" survey will also provide ongoing evidence concerning the emphasis that UK companies are placing on innovation and the level of recognition that as a process, it impacts directly across all aspects of their businesses.

3. Patents & Licensing Activity

Patenting activity is a major indicator of R&D and innovation activity. In 1995, the UK patent office received 26,739 applications and granted 9,475 patents, of which 3,648 (38.5 per cent) were from UK residents. This figure has remained fairly constant since 1991, when 9,346 patents were granted, of which 35 per cent came from UK residents (Source: UK Patent Office). It is significant that the most prolific patent users in the UK are overseas companies (eg Samsung, Motorola, Mercedes Benz, Bosch, Sony). The highest ranked UK firm is British Telecom who were granted 78 patents in 1995 compared with Samsung's 221.

The Innovation Trends Survey 1996 reported a decrease in patenting and licensing activity in 1995 over 1994, with only 62 per cent of businesses committed to patenting. In 1991, patenting activity was reported to be fairly steady, with a slight decrease expected the following year. The overall trend over the period is therefore one of minimal change.

There are no national statistics on licensing activity, either inwards or outwards. Anecdotal research suggests a slight increase in the past few years in licensing activity by UK firms. However, since many firms are hesitant to reveal information about confidential licensing arrangements, it is difficult to get any real picture of the present state of licensing trends.

Statistics are available for income from intellectual property in the UK universities though it is unclear whether this is from licensing, outright sale or other methods.

In academic establishments, licensing out of developments is still at a very low level. Income from IPR in UK universities in 1995 totalled a mere £7.7 million, of which over half (£3.9 million) was generated by Scottish Universities (Source: HESA). These figures do not take account of any separate companies set up as spin-offs to exploit technical R&D.

4. SME Performance

The failure rate amongst start-up businesses is unacceptably high. Research by the Small Firms Lead Body indicates that one third of businesses fail within three years. The reasons for this failure are not financial, but related to management and marketing weaknesses. The NatWest SBRT Quarterly Small Business Survey of November 1996 revealed that the most important problems for small firms in descending order are:

— low turnover/lack of business (32.8 per cent)
— government regulations and paperwork (11.2 per cent)
— cashflow/payments/debts (9.5 per cent)
— lack of skilled/trained employees (7.7 per cent)
— competition from big business (7.2 per cent)
— total tax burden (6.2 per cent)
— premises/rent/rates (3.9 per cent)
— internal management difficulties (2.6 per cent)
— access to finance (2.6 per cent)

Since 1991, the top three problems have remained constant, with low turnover even more of an obstacle than in 1991.

The survey also indicates that the motivation behind many SMEs is not sufficiently innovation-orientated. The main objective of these firms is cited as "to support preferred lifestyle" (35.2 per cent) followed by "growth in profits" (21.2 per cent). Only 6.1 per cent see their main objective as being to grow the business through sales or 0.5 per cent through employment. The existence of a very large number of "lifestyle" businesses amongst the small corporate base must have an influence on the general performance of small and medium sized firms. Moreover 27.6 per cent wish to remain at their present size, and 9 per cent have no growth targets at all. Only 33 per cent have a growth objective.

SMEs are the main source of innovation. They are more flexible and responsive than large firms and produce four times as much innovation per R&D spend as large firms. They have highly specialist technical skills, often unavailable to larger firms.

Our own research at Innovation & Growth Unit indicates that the main causes for failure amongst innovative SMEs are largely management and marketing oriented. Whilst not exhaustive, the following list includes some of the more significant reasons for failures:

— poor planning skills and lack of understanding of the planning process
— lack of marketing expertise, in particular market research skills, strategic marketing, poor forecasting, tactical ignorance
— financial naivete' and lack of commercial awareness
— severe short-termism.

Whilst there are many other factors inherent in innovative businesses, the above are all capable of being improved through education, training and management support.

It is also worth noting that while our research indicates that levels of technical innovation within SMEs are very high, marketing innovation and management skills to exploit this expertise are very low. Indeed, it is poor management and marketing planning which frequently prevent otherwise good propositions from being "bankable".

5. SME Profiles

There are significant numbers of technology-based and innovative firms. *DTI Small Firms Statistics* in 1995 reported there are 3.6 million active businesses in the UK, of which 2·6 million were "one man bands". Our research indicates that of this only 146,000 firms have a high technology content, either as a marketable

product/service or a means of production. Of these, 96 per cent have turnovers under £5 million, and can be described as small or medium sized firms. The number of enterprises engaged in the technology field are increasing, with areas such as IT Services, which accounts for nearly 40 per cent of all these firms, rapidly altering the corporate profile of the country. Moreover, new types of businesses such as "virtual companies" are now being established.

It is clear that with such rapid changes occurring in the structure of the UK's economy, the need to understand the dynamics of these new enterprises will be vital to their success.

This is further emphasised by other recent studies into growth businesses, which indicate:

- technology sectors have higher concentrations of growth businesses than other sectors (eg DP equipment) (David Storey: The Ten Percenters)
- young businesses are more than three times likely to be rapid growth (David Storey: The Ten Percenters)
- average growth of smaller, younger firms is higher than larger, older firms
- lack of innovation is one of the more important internal constraints on growth
- companies investing a higher proportion of turnover in innovation grow more quickly (Arthur Andersen: *The Pulse Survey*)

Q2. *How successful have the Department of Trade and Industry (DTI) and other Government Departments been with their range of initiatives designed to stimulate innovation?*

Research undertaken by Innovation and Growth Unit, NatWest UK in 1995 into innovative businesses revealed a very low level of usage of government initiatives. For example, none of the businesses in our sample of young innovative firms (the target market for the initiatives) had sought help from TECs or Business Links. (This reluctance to use external sources is not confined to government schemes however. There was a similar neglect of commercial sources such as design and marketing specialists.)

Anecdotal evidence from our customers suggests a high degree of confusion about the roles of Business Links, TECs, Chambers of Commerce and Enterprise Agencies. There is also scepticism about the quality of advice given, and certainly in our experience of dealing with Business Links the quality of the advisers is very variable. The Innovation & Technology Counsellor (ITC) concept is an excellent one, but the same doubts surface over the abilities and quality of the individuals.

As an example, our New Technologies Appraisal Service (NTAS) has been made available to ITC's under the Innovation Credits Scheme, whereby the Bank will undertake NTAS in conjunction with an ITC. The NTAS scheme has been proven to be an excellent tool for appraising innovative businesses and offers many advantages for growing firms. It is therefore surprising that no NTAS reports have been commissioned on this basis.

A further factor hampering the uptake of Business Link services is their previous reluctance to work with firms of under 10 employees. Since a very high proportion of all SMEs fall into this category, it makes little sense to exclude them from this service provision. It is understood from talking to a number of Business Link Chief Executives that enterprises with fewer than 10 employees are now being accepted, though many Links still do not.

Other initiatives run by the government have had varying success:

- SMART/SPUR provides an excellent source of funding for SMEs, and has helped to get many companies and products launched successfully. Since the changes in the criteria, greater emphasis on marketing, and the introduction of patent searching, the schemes have become more focused, providing a good indicator to investors of the technical viability of particular projects. As a "selector of excellence" SMART and SPUR offer investors important guidelines. However, SMART and SPUR are limited in terms of numbers of companies they can help, and many who fail to get funding could have equally profitable projects. The provision of a "clearing house" for projects that fail under SMART/SPUR but which might prove useful to larger firms might significantly increase the number of successful projects.
- DTI Innovation Unit—the sustained activities of the DTI Innovation Unit, which draws secondees from a broad range of commercial/industrial disciplines, have been a major influence on the overall innovation debate. The combined expertise and experience of the secondees adds a powerful voice to that debate whilst also enabling a more effective introduction of Best Practice into UK industry.

However, in our experience, there is still a general low level of awareness amongst SMEs of government initiatives, confusion over how and where to get assistance, and some doubt as to the efficiency of the schemes.

The National Audit Office report of 1995 into the DTI's Support for Innovation Schemes concluded that schemes designed to facilitate implementation of best practice or new technology, such as TCS, are rated more highly than general awareness schemes. In 1992, 77 per cent of the DTI's innovation expenditure was orientated towards technology development with only 2 per cent to best practice and 21 per cent to technology transfer. In 1996 the emphasis has moved to technology transfer (48 per cent), with technology development

at 45 per cent and best practice at 7 per cent. This move towards implementation and technology transfer (now called "technology access") will only work however if there is better education of SMEs on the definition and role of technology transfer, which is still not well understood.

The most recent initiative is Technology Foresight. For many SMEs, Technology Foresight appears to be irrelevant, and many are unaware of it altogether. Innovation Trends Survey 1996 reported that 52 per cent of manufacturers were unaware of Foresight, 20 per cent were aware but not involved, and 28 per cent were involved in one capacity or other. Most of this involvement has been in the form of Delphi questionnaires or participation in Regional Workshops. The survey also showed that 56 per cent of manufacturers believed innovation support from both UK and EC governments to be inadequate, with 30 per cent believing them adequate.

The Challenge competition, for which winners were announced in June 96, reveals that 35 per cent of all businesses in the bidding consortia were SMEs (117). Whilst this is encouraging, it is in no way a major success story and Foresight is still largely the province of large firms. There is considerable evidence that SMEs are not only unaware of Foresight but are finding it difficult to translate the results of Foresight into meaningful business benefits. Far greater emphasis needs to be placed on identifying practical benefits for SMEs and giving them access to them. In this regard the Institute of Physics have established a programme to help SMEs access Foresight developments.

Q3. *How effective in terms of product or process innovation and other exploitable outcomes are initiatives which encourage collaboration between industry and academia?*

Most HEIs have established individual posts or separate companies to exploit their R&D, identify suitable commercial partners, to develop the product to market, or establish licensing agreements or spin-off companies. Some have had successes, but many others have failed to identify and develop a critical mass of exploitable technologies which provide momentum and income to the university to continue the process.

One of the reasons for this failure may be the lack of industrial and/or commercial input into these enterprises, many of which are run by former academics rather than industrialists.

Through its network of trained Technology Business Managers (TBMs), NatWest has close links with higher education institutes in the UK. Where possible we have assisted in a number of technology transfer projects and spin-off companies. Many of these companies exhibit the same weaknesses and deficiencies displayed by all innovative business start-ups:

- Where a technology, product or process has been nurtured within the university, the university is often prepared to release the technology/intellectual property at a rate significantly less than its commercial value.
- The quality of advice and support given by the university to potential spin-offs varies with the calibre of the Industrial Liaison Officer.
- Many display a surprising lack of understanding of the social/business sciences, for example, well founded technical research, but limited and unsubstantiated market research.
- Typically a large number of academic spin-offs are soft starts and trade for a significantly longer period than planned to develop into manufacturing businesses.

Some of these observations also apply to non-academic start-ups.

On the positive side, we do know of a number of HEIs who have extended significantly their involvement with government and European grant schemes. For example, Liverpool University (note: Objective One Area), have over the last two years secured over £15 million from European Structural Funds for projects which are much nearer market and have a direct benefit on the local industrial community. Equally, several of the Welsh universities are actively involved with Europe, supported by the WDA.

Q4. *Does financing need to be improved for technology-based small firms during their crucial start-up and early development phases?*

Previous Reports (*House of Commons 1994, Science and Technology Committee 1994, Bank of England Report 1996*) confirm that there is sufficient funding available for innovative SMEs, but that there are failures on both sides (entrepreneurs and financiers) in matching up the most appropriate funding to the business at its particular stage of growth. The main problems are:

- Particular types of funding may be misunderstood or misapplied by bank customers. For example, overdraft, which is primarily a tool for working capital, and which accounts for 42 per cent of small firms borrowing, is frequently used to try to fund longer term projects (an estimated 15 per cent). Whilst the proportion of medium and long term loans is increasing at NatWest (now 72 per cent of our £8 billion lending), and over a quarter of our Business Development Loans are for more than 10 years, there is still a severe short-term mentality amongst SMEs.
- The level of management and financial expertise within SMEs is low. For technology and many innovative businesses it may be even lower, founded as they are by highly skilled technical personnel

with minimal management experience. This lack of expertise and experience in early stage SMEs is a major factor in the high failure rates. It could be tackled either by increased education and training of owner/managers or by increased management input from outside the enterprise.

In financing terms, the most important failure is in the provision of small-scale equity in the start up and early stages of growth.

— Venture capital firms in the UK invested £2.1 billion in 1995, over twice as much as in 1991 (£989 million) and 28 per cent more than 1994. However, whilst the total amount invested is increasing, the amoung invested in early stage business has been declining in proportion terms, and in 1995 represented only 3.9 per cent of all funds. Venture capital has moved away from "venture" and towards development or merchant capital in the form of MBOs/BMIs, where the returns are potentially greater, and the risk perceived as being far less.

— At the same time, the average size of deals is increasing (£783,000 in 1991, £1.8 million 1995) and the sums invested in early stage technology are small: £47.6 million in 1995, or just 2.2 per cent of the total. The reasons for this reluctance to invest in early stage technology can be traced to the "boom" in the mid to late 80's when many technology firms were invested in and failed. This is now acknowledged by the UK industry as being largely the result of poor post investment support, and a misunderstanding of their needs, financial and management.

— The result is that it is becoming increasingly difficult for technology SMEs to get early-stage, small scale investment from the traditional venture capital industry. In 1995, 233 technology companies received venture capital investment. NatWest estimates that there are 146,000 technology businesses in the UK. If only 4 per cent of these have potential to grow (cf David Storey, Warwick University) this indicates that some 5,800 businesses are potential recipients of equity/risk capital for growth.

— There is evidence that the venture capital industry which is now mature and highly sophisticated, needs to develop a new "arm", perhaps indeed to re-invent itself, so that it can operate under the original concept of providing risk capital to early stage ventures. This concept dominates in the US, where venture capital is primarily regarded as high risk, early stage funding.

— There are a number of venture capital houses which specialise in funding early stage technology firms (eg MTI Managers, Prelude Technology). Their approach is very different to that of mainstream venture capital firms, in that they operate far smaller portfolios and put considerable emphasis on post-investment support. As a result, their returns and success rates in technology are far higher than those for more generalist funds. A more extreme view is that non-specialist funds who do invest in technology firms may be doing actual harm, since they do not provide the management support these firms need, and hence firms which have basically excellent ideas fail when with greater management input they would have far greater chance of success, or of breaking through into the market earlier than they do.

The interface or transition between debt and equity in start-up and early stage businesses is a major stumbling block and source of confusion. NatWest's approach, through Innovation & Growth Unit, has been to:

— develop funding packages which are *appropriate* to the business, are flexible enough to allow the business to grow, and which take account of all sources of funds (debt, equity, free monies)

— train and educate our Managers to give more appropriate guidance to technology customers rather than simply turning down the request or giving then inappropriate finance

— educate customers in the different types of funding available, as well as other major issues affecting their development

— launch a national Business Angels Service to stimulate activity in the informal investment marketplace. In addition to providing funds, Business Angels also bring considerable experience and mangement expertise to the business in which they invest—this can often be as important as the investment itself.

Q5. *What other support systems could be introduced to ensure that the maximum advantage is taken of innovative ideas that originate with individuals or, for example, in academia?*

1. Training

Good ideas by themselves do not make businesses. Innovators or entrepreneurs with innovative ideas need to be identified at an early stage and provided with practical and professional help in basic management and financial and marketing functions. As a symptom of this, the standard of business planning amongst SMEs is very poor, with our research indicating only 18 per cent of plans submitted as being good, and 54 per cent as being poor or very poor. Similarly, understanding of fundamental marketing is very poor amongst innovative SMEs. Improved early stage training is needed, as an example, the development of an *Innovation Handbook* may be worthwhile. This initial training then needs to be reinforced by the use of mentors on an on-going basis, to enable the business to cope with rapid market and industry change.

2. Mentors

High growth oriented firms are more likely to succeed when led by multi-skilled management "teams". Experts must be introduced into a growth business at an early stage, before fundamental commercial mistakes are made which can delay or seriously damage their rapid development. This expertise must be provided at a price the entrepreneur is able—and willing—to pay, whether this be in cash, or giving up some control of the business in the form of shareholding. This could be achieved through:

— a structured, nation-wide mentoring service. NatWest's Business Bridge or Business Angels Service provide starting points the use of corporate mentors as well as individuals. A recent addition was the launch of the NatWest Corporate Angels Service and will also provide a useful starting point.

The existing supply of mentors in Business Links (PBAs) are not generally perceived as being of good quality, and a far more professional network needs to be established.

3. Corporate Venturing

Business Angels are increasingly being perceived as a major source of investment and management skills. The role of corporate angels is as yet relatively unresearched, but NatWest Angels Service has recently launched a Corporate Angels Register based on our awareness of the potential impact such investors can have on SMEs. The use of corporate angels is particularly useful for technology firms:

— rapid access to markets, sales and distribution routes
— access to resources and facilities they could not themselves fund
— access to much needed to hands-on commercial and managerial expertise
— greater credibility with customers
— sources of risk capital

For the corporate venturers themselves the benefits include:

— access to highly specialised skills and expertise
— access to new technologies and innovations
— strategic advantages
— greater social policy credibility amongst all its public

4. Academic Incentives

Far greater incentives need to be given to academics to regard their R&D in terms of its potential exploitability. Possible schemes could include:

— a small percentage of each grant to be ringfenced for commercialisation, whether in terms of patents, market reviews, consultancy etc.
— changes to the citation system which encourages early publication at the expense of exploitation of commercial ideas
— far greater training of academics in the commercialisation of their ideas, and changes in the basic culture operating in HEIs which currently does not encourage academics to establish commercial enterprises, as is the case in the US.

5. Centres of Excellence

The development of more well-recognised and well-publicised Centres of Excellence in individual disciplines (eg biotechnology, electronics) would held to produce greater understanding between financiers and the technology community. Similarly, initiatives such as 'Biotechnology means Business' should be expanded to other areas, with greater emphasis on the finance/technology interfaces.

Q6. *Is there institutional inertia towards the funding of technology-based small companies? If so, to what extent may this be due to financiers' unfamiliarity with science and technology concepts and what should be done to address this?*

There has traditionally been an unwillingness on the part of institutions to finance technology SMEs. NatWest recognised this in the late 1980s and set up Technology Unit, now Innovation & Growth Unit. The Unit has had considerable success in identifying, supporting and maintaining technology SMEs, with benefits for both customers and the bank itself. This lead has not been followed by other banks, none of whom have established similar Units, or even developed alternative products and methodologies. The fact that our approach works is demonstrated by our market share in this sector, currently standing at 41 per cent (16 per cent in 1989).

This reluctance by other banks to adapt to a clear market need (increasing numbers of technology firms, encouragement from government to promote and stimulate technology and innovation, and the need for the UK to base economic prosperity on new technology) is the result of a number of factors:

— unfamiliarity with technology concepts
— fear of risk for which most traditional banks are not geared

— misperception of technology and innovative firms as high risk, and hence to be avoided. In reality, technology enterprises may be far less risky, provided they are *appraised realistically* pre investment and supported well post investment.

— misunderstanding of the financial and commercial needs and dynamics of technology SMEs.

These factors all form part of what the Innovation and Growth Unit refer to as the Empathy Gap: (see enclosed) a breakdown in actual and commercial understanding, and diversity in expectation of the two parties.

This gap can be bridged, and at NatWest we do this by:

— a network of Technology Business Managers located in branches throughout the country, delivering rapid and practical support

— a cost effective appraisal service to assess the true potential of businesses and their innovative technologies and products

— a dedicated technology and market information service for Managers to help them make well informed decisions

— local and national networking to give customers access to professional guidance

— a flexible response to customers' changing needs throughout their start-up and expansion phases

— packaged funding which is truly *appropriate* to the needs of rapidly growing firms, and which does not put them in a financial strait-jacket

— a bank culture which is sympathetic to technology and innovative enterprises, whilst retaining the ability to appraise risk effectively.

At the same time, companies themselves must try to understand more about financiers' needs:

— improving their financial and management skills and demonstrating their ability to monitor and control the business

— developing greater awareness of the range of finance available, and accepting that some propositions are not suitable for bank finance alone

— considering long term loans or equity investment in preference to overdraft, even if it means relinquishing some control

— improving long term planning, with more emphasis on marketing as the key to innovation success

— working with their Technology Business Manager from an early stage in the business's development.

Q7. *The Committee recommended tax credits for research and development in our previous enquiry. Would this still be an effective way of fostering innovation and how should they be introduced to ensure that they are roughly cost-neutral?*

Innovation has been defined as the successful exploitation of new ideas, although we would substitute *profitable* for *successful*. Innovation should therefore be a culture that permeates throughout the company, requiring good management of all the company functions. It is often confused with invention and R&D but these are only components in the success of a company.

In order to capitalise on R&D it is crucial that there is a recognition of market needs as well as those mechanisms which will take a product or process through to the market place as rapidly as possible.

The expenditure indicators in the 1996 CBI/NatWest Innovation Trends Survey, suggest that an increasing number of companies are recognising the contribution innovation makes to their competitiveness and efficiency.

Therefore, it must be accepted that pure taxation benefits are not the main driver of innovative activity, but any amendments to the taxation system which frees up self-generated funds for investment in innovation would receive a broad welcome from the business community. However, it must be clearly understood that the introduction of associated complex bureaucracy will undoubtedly exacerbate the "management expertise" problem in many SMEs, (particularly at the lower end) perhaps resulting in a decline, rather than improvement, in innovation with SMEs.

Notwithstanding this, Government should consider the following proposals:—

— An increase (to, say, 150 per cent) of expenditure on R&D to be exempt from Corporation Tax. This allowance to be based not on total expenditure, but on the amount of real additional expenditure which a company makes over it's previous years total. (As recommended in the Select Committee on Science and Technology report on "Innovation in Manufacturing Industry"—Jan 1991).

— Businesses to be permitted to write off R&D expenditure related to innovation in product/process in line with the proposal above, not just in the year incurred, but against future profits within strictly defined criteria to conform with Standards of Accountancy Practice. This reflects the fact that

investment in innovation will often not produce a profitable return for a number of years, especially at the start-up and early stage development of a business.

— The incentives need to be carefully thought out to ensure that investment in innovation is not carried out just for taxation benefits. The imposition of a system of limits/maximums may be necessary to limit the cost of the proposal and to effectively bias it's influence towards the smaller innovative business. A time limit of say three to four years also needs to be considered in relation to the "future profits" recommendation.

The proposals are aimed at stimulating continuous investment in innovation, particularly in the smaller business. For start-up and early stage businesses the retention of cash in the business is vital to future survival, let alone growth.

In our considered view it would be highly unlikely for these proposals to be introduced on a cost neutral basis. However, the benefits to the economy of UK PLC, in terms of increased permanent employment, business profitability, export performance etc would generate revenue to the Government from other sources to offset the costs involved.

In addition, to reduce the overall taxation burden on SME's in order to foster an environment of job creation and investment, the NatWest Group Chief Economist has recently stated that the Government should consider the following proposals (Chartered Banker *January 1997*—Journal of the Chartered Institute of Bankers):—

— Increasing, possibly to 100 per cent, the first year capital allowance on the first £200,000 spending on plant and machinery.

— Raising significantly, say by 25 per cent, the profit limits applied to the smaller firms' 24 per cent (23 per cent wef 1/4/97) corporation tax rate and/or lowering the smaller firms corporation tax rate—initially to 20 per cent and, in the longer term, to 15 per cent.

— Extending the Enterprise Investment Scheme (EIS) to existing owner-managers, to encourage investment.

— Extending further the exemption from inheritance tax and abolishing capital gains tax for disposals made 4 years after acquisition.

— Raising considerably the turnover threshold at which businesses start paying VAT.

Since some of these proposals may require the consent of the European Commission, the UK could make such a proposal the subject of a wider EU initiative. Focusing changes in corporate taxation on SME's could enhance flexibility in the labour market and stimulate investment in innovative products and processes.

Q8. *How has the Technology Foresight Exercise influenced the availability of development funds for innovative ideas that were not given short-term high priority status?*

Technology Foresight is central to the Office of Science and Technology's (OST) agenda. The Foresight Programme reflects three principles of the 1993 White Paper "Realising our Potential":—

— the need to make judgements about priorities in allocating finite resources for Science and Technology, and these judgements must take account not only of UK scientific strengths, but also of potential to lead in due course to exploitable outcomes.

— the setting of priorities should not be imposed but should be the result of dialogue between the users of research (ie commercial organisations) and the providers of research (HEIs).

— the key to improving the UK's effective exploitation of its science and engineering excellence is to bring the business and scientific communities into closer contact with each other, in order to break down the cultural barriers that exist.

Foresight embodies all of these principles, with its twin objectives of:—

— establishing partnerships at all levels between the science base and industry (to increase mutual understanding, cross fertilisation of ideas and to effect a culture change).

— using consensus about market opportunities and key technologies to inform decisions about prioritisation and resource allocation both within the public sector and in business.

The existence of the Foresight Programme is a major achievement and the sustaining of the initiative across 16 economic sectors is a significant commitment. UK business needs to be ready to innovate; to be more receptive to new technology; to be more willing to invest in "Development" which is essential to build on the know-how and skills that the science base offers. The R&D Scoreboard, which lists UK companies' latest reported investment in R&D indicates that, compared to our main global industrial competitors, UK industry's R&D investment record is relatively poor.

The next phase of the Foresight Programme must be to influence the culture and attitude which underlies UK's companies' consistent record of poor investment in R&D and innovation. The Foresight Programme has certainly led to a good response from the UK science base, but, as yet, has failed to fully engaged UK industry, particularly at the lower end of the SME scale; indeed the latter has been virtually ignored yet their involvement is crucial to the success of the whole programme.

The CBI/NatWest Innovation Trends Survey 1996 included a number of questions aimed at the penetration of Foresight into the business community. The responses to the survey highlighted significant differences between manufacturing and non-manufacturing companies' involvement in Foresight. The numbers of manufacturing companies who responded to the survey who said they were involved or aware of Foresight, were well above the non-manufacturing respondents. However, the most startling feature of the survey responses was the high percentage of companies who were completely unaware of Foresight—52 per cent of manufacturing respondents, 72 per cent of non-manufacturing respondents.

However, the numbers involved with Foresight can only be an indicator of participation and not an output in itself. Targets must be developed to improve participation (at the micro-level) and also at the macro-level in terms of targets for GDP and improvements in the competitiveness of key sectors.

If the Foresight programme is to enhance the level of innovation and competitiveness in the UK in the long term, it is essential that a clear strategy is developed to extend participation to SMEs, share information with them, encourage their collaboration and provide the prospect of shorter term returns, whilst acknowledging the long term aims of Foresight.

To achieve these aims it is essential that the Foresight programme penetrates beyond the R&D functions of companies to the key business decision makers and opinion formers in larger companies, and encourage smaller SME companies to become involved through active promotion of collaboration and innovative practice implementation, possibly through the DTI, Business Links and RTO's.

In terms of influencing the availability of development funds for ideas that were not given short-term high priority status, it is estimated that some £300 million of public and private funds have been reoriented to this initiative since its inception, but it is difficult to determine what percentage of this money is new or merely redistributed from existing budgets. It is similarly difficult to assess whether more funds are now available for innovative ideas that were not given short-term priority status. The Foresight programme has certainly highlighted the need to focus funding on commercially exploitable research.

Q9. *Has the tax relief introduced in 1992–93 for individuals' expenditure on vocational training had any impact on the status of continuing professional development, in particular for employees in small firms?*

Within NatWest, to our knowledge and with limited levels of consultation, we believe information on this issue is not maintained and it is difficult for us to comment on this specifically.

However, from discussions with relevant parties (support organisations, CBI, DTI and SME's) it is clear that greater emphasis is being placed on the training of staff to meet the increased skills requirements demanded by the increasing level of technological advancement. Many larger firms are emphasising continuing professional development as a means of broadening the experience and adaptability of their staff.

Memorandum by Pax Technology Transfer Ltd

Executive Summary

The transfer of technology into a company from other companies, local or foreign, from universities and research institutes and indeed from inventors can be an effective mechanism for innovation.

We at Pax "believe in" technology transfer for UK industry and we therefore have a double interest—firstly as concerned and committed citizens, and secondly as participants in Pax Technology Transfer Ltd to which we have committed our careers and our capital.

We believe that many of the DTI's activities with respect to technology transfer over the last 10 years and more, at best have not been cost effective and at worst, have been counter productive. We refer particularly to the Regional Technology Centres and to the TECs and Business Links. The initiatives, programme rollouts, branding and endless publicity have built hopes and expectations; the results have been hard to see, and where they have been visible seem trivial when set against the cost to the taxpayer; the widespread disillusionment with the many confusing DTI programmes has not enhanced the cause of effective technology transfer in the UK, as far as we can see.

Many of the programmes have inhibited or suppressed the growth of valuable and market sensitive private sector technology transfer services.

We believe that public funds could be better spent in improving the supply of well trained and motivated scientists and engineers to medium size companies—starting perhaps with short commercial awareness programmes for post graduates.

Initial Comments

In this evidence I would like to touch on a number of issues:

— The DTI "Model"—supply side/demand side

— Programme effectiveness

— Market confusion
— TECs and Business Links
— Integrity issues
— Centralised versus pluralistic structures
— Friendly fire/collateral damage
— Conclusions

But, before I do so, let me outline my own credentials and perspectives.

Pax Technology Transfer Ltd

I am Managing Director of Pax Technology Transfer Ltd, a leading private sector technology transfer facilitating and consultancy company established in 1978. In 1988 it merged with its main competitor, Shekell Mooring, whose roots go back to the early 1970s. The company specialises in finding valuable technology for industrial companies and in advising on all aspects of licensing, from setting up agreements to acting as expert witness in patent infringement cases. It also provides marketing support to innovative companies and, selectively, to inventors. It serves clients in the UK, continental Europe, USA, Japan and elsewhere.

We have worked on a number of European programmes, including SPRINT, VALUE, COMEX, EXPECT etc, and have contributed to the "Good Practice in Managing Transnational Technology Transfer Networks" study for the SPRINT programme, in which one of our projects has the star role. We have organised technology transfer conferences and match making events in Europe, the Far East, and North Africa on behalf of the European Commission, and contributed to a DTI UK "road-show" on technology transfer.

Pax has provided technology transfer services—mostly finding technologies for license—to the former Scottish Development Agency and the Welsh Development Agency; we have interacted with regional technology centres and we have been members of Nimtec. We have run technology transfer programmes supported by one TEC and have given seminars for others; we have talked to many Business Links and contributed to training events for Business Links' Innovation and Technology Counsellors.

We have not carried out "studies" or surveys, but we have been totally committed to technology transfer for nearly 20 years—during which period we have operated commercially and profitably despite significant competition, not least from government ministries and other agencies offering allegedly similar services "free" or virtually free to the user.

During 1996, for example, I personally had 126 face-to-face discussions with Chief Executives or senior Directors of UK manufacturing companies about their strategic plans and technology needs. I estimate that I must have spoken to nearly a 1000 more on the telephone during the year. In 1996, we worked on many industry sourced projects and interacted on some 90 projects with 34 UK universities and institutions of higher learning in the UK—and twice as many with overseas universities and research organisations.

I was Chairman of the Institute of International Licensing Practitioners (IILP) from 1985 to 1993 and I am currently a member of the IILP Executive Committee. I am a member of the Executive Council of the Licensing Executive Society of UK and Ireland. I am also a regular guest lecturer at Cranfield University R&D Management Centre.

DTI Model

In their speeches, ministers and senior DTI officials talking about innovation and research and development seem to imply that research leads to development, which leads to products, which leads to successful industrial exploitation. The implication is that if we could but get the research out of our universities and into our industry, all will be well. In a recent letter asking for feed-back on technology transfer programmes the Deputy Director of the DTI's Management Best Practice Directorate talks of the "problems faced both by the 'supply side'—primarily the science, engineering and technology base—and the 'demand side'—primarily business and business support organisations such as Business Links". I think that this supply and demand model is deeply flawed and, for different reasons, the Business Link structure is also flawed.

The "supply side" is far greater than the UK science base—the UK science base is but a modest part of the total. The "supply side" should include the international science base and other companies in the UK and internationally. The critical function of the UK universities should be to produce well educated, motivated and resourceful scientists and technologists who also understand the basic elements of the commercial exploitation of technology—contract law, intellectual property, licensing, company start-ups, etc. Research results from the UK science base should be exploited in the most effective way possible and, we believe, if that means exploitation outside the UK—so be it!

On the "demand side" of the UK economy, the demand is for technology for high-tech start-up companies and also for technology to enhance and update existing companies. The demand from industry and commerce is indifferent to the source of the technology, whether it is from the UK or from overseas, from university or from another company, providing it is appropriate and transferable without undue difficulty.

Intermediaries such as Pax or Business Links represent "demand" only in as much as they are effective in representing the requirements of individual companies. There is no evidence to suggest that technology transfer is a large enough field to justify or support a hugh network of intermediary operations, public and private sector, across the UK.

DTI Programme Effectiveness

Technology transfer is a popular theme and appears in many of the DTI's business support programmes. Some, such as SMART, have merit in encouraging small scale innovators and giving them some publicity. Others such as the Regional Technology Centres seem to be dying away, although a few still remain supported, it seems, by grants and special "contracts". Certainly many industrial companies have been contacted by these Centres but I have yet to hear of any that has benefited in any significant way. The publicity machine's claims on "successes" are plentiful, but the "successes" seem trivial in relationship to the investment. Most industrial organisations with contacts with Regional Technology Centres seem to have given up interest in them.

One has to ask what the thinking is behind the DTI's "International Technology Promoter" programme. Why is the taxpayer supporting a handful of technology liaison people when plane-loads of technologists and business people of every specialisation leave and return to our shores every day?

What is the thinking behind the new industry-government "partnership", the "Information Society Initiative"? Who needs a bureaucratic organisation across the county to find out about IT systems or the use of e-mail and the Internet? Any high school could provide instant experts. There are endless magazines on the book stalls and dozens of local companies organising themselves to serve this market. How can a DTI appointee be expected to be wiser, more reliable and more up-to-date than a skilled consultant or a responsible supplier?

We are, frankly, not aware of any significant "successes" for which a DTI programme has been instrumental or crucial in the successful transfer of technology. We presume there must be some of which we are unaware. Recipients of grants will always give generous acknowledgements to donors and therefore the DTI's successes are only those which would not have happened without the DTI programmes' support.

I am aware of other DTI programmes, including the Teaching Company Scheme (TCS), the Shell Technology Enterprise Programme (STEP), Post Graduate Training Partnerships (PTP) and College Business Partnerships (CBP) but I have no direct experience of these and therfore cannot comment on their effectiveness.

Market Confusion

In addition to the DTI programmes, there are business support and information services subsidised by the European Commission, in particular the BICs and the EuroInfoCentres—to say nothing of the still existing Chambers of Commerce, local enterprise agencies, etc, etc.

On top of this costly public sector supported profusion of agencies, the new Business Links are being imposed.

TECs and Business Links

It is my understanding that the technology transfer activity of the Business Links is, in due course, supposed to be self supporting, or at least partly self supporting. Without substantial grants or "contracts" from the DTI and other benevolent public sector bodies, the few that might possibly achieve this will only do so by proving substantial added value, presumably by providing, inter alia, technology transfer services—and thus compete directly with the service providers.

With respect to technology transfer, it seems that if the Business Links fail they are not worth having, and if they succeed they will do so at the expense of the young private sector technology transfer industry that is trying to develop. An organisation that creates such alternatives is flawed in concept.

Business Links, with respect to technology transfer, seem to offer just another layer of bureaucracy between the supply side and the demand side—and theirs is a centralised and potentially domineering bureacracy that would be more appropriate for the old Soviet Russia than for a modern society in which information is so readily available.

The Business Links are now also spawning other strange trades, including writers of grant applications and for-profit companies to give quality control approvals to consultants—sprung up from nowhere. Their authority seems to come only from the taxpayers' purse. Between the technology supplier and the technology user we now have a proposal writer, one or two Business Links (and their partners), a technology assurance organisation as well as the technology transfer consultants who facilitate the deal.

Very few Business Links will be able to generate sufficient technology transfer activity to develop the range of assets and skills required for efficient operation—industrial knowledge, international contacts,

understanding of intellectual property law, etc—to complement their business and financial skills. (Similarly, few cottage hospitals have the skills to provide specialised organ transplant services.)

The high quality of the Business Links' publicity material raises expectations of quick and simple solutions. Arranging technology transfers is usually long and difficult and will benefit from the resources and skills of full time professionals. Real quality help will not be readily available from Business Links and potential users of technology transfer services will become disheartened by the process.

For TECs and the Business Links to provide technology transfer support to industry, all they need is a list of professional associations such as the Licensing Executive Society, Institute of International Licensing Practitioners etc., and a list of technology transfer consultants (it will not be very long), for those who need professional help. For those who wish to try and make the contacts and arrangements themselves, help with access to directories and databases can be offered.

The theory, I understand, is that the Business Links refer companies to organisations with the consulting skills they may need. In practice, the Business Links seem to be creating a cumbersome bureaucracy for delivering a rag-bag of grants, freebies and subsidies which are exploited by companies and consultants with little better to do!

Integrity Issues

Our greatest concerns are the reduction in transparency and equity and the conflicts of interest which flow from major DTI programmes relating to technology transfer. These are not in the public interest nor are they (see next section) in our private interest.

We recognise that, if the public sector is to act in any way, there will inevitably be some market distortions, but we do not think that implications have been adequately addressed by the DTI. The result has been a spread of cynicism, excess "working of the system" and damage to the cause of innovation. Let me suggest some examples:

— "Partnership between government and industry". Partnerships usually mean shared risk. As far as I can understand the bulk of the money, for example, for the TECs and Business Links comes from the DTI or DFEE. The new Information Society Initiative is another "industry-government partnership". Who is taking the risk? Language itself is devalued.

— Business Links' PBAs often work part-time, eg two-three days per week for the Business Links. The rest of the week they work as independent consultants on their private account. This can lead to clear conflict of interest as the PBA will inevitably be tempted to do his marketing and publicity at Business Link expense and then cream off the better paying jobs for his private practice. The problem can be compounded if a PBA is instrumental in gaining for the industrial client a grant—regarded as "success" by the Business Link!—which could help fund the client's private fees for the PBA.

— If the Business Links are to become financially more self sufficient, as I believe is the intention, then they will have to provide much more added value—which means competing directly with their service providers. Such competition would be grossly unfair, as the Business Links would be highly subsidised, will have access to the service providers know-how and may have even "branded" the providers' services in the Business Links' name.

— There is a publicity machine related to the Business Links which pumps out success stories on a regular basis. The successes appear to be extremely modest and out of proportion to the enormous investment by the taxpayer. Intelligent debate is clouded by the "publicity speak". What surveys of success have been completed and have they been published? One can read about the tiny crumbs of success written large, but what is the cost for what success?

— If the Business Link movement is "successful" the power of the Business Link executives will be very great, for example to determine which company gets a subsidy or which consultant gets a lucrative contract. This unwholesome power will derive from the weight of the money taken from the taxpayer and not necessarily from reputation or achievements. As the movement develops in power and influence, the risk of conflict of interest, to say nothing of kickbacks, will be immense.

— I note that many of the TECs and Business Links are partially paralysed—at public expense—for several months a year while they wait to see if they are going to get their next grant or "contract" from the DTI. They seem more like dependants on the DTI than partners.

Central versus Decentralised and Pluralistic Structures

The collapse of the Soviet Union's economy is a powerful example to suggest that a highly centralised organisation is unlikely to be efficient. UK plc might allow technology transfer services to grow and develop in response to market demand or, alternatively, such services might be organised as an exclusive public sector exercise by the DTI, essentially through a strong and expensive network of Business Links. If the aim were that public and private sector technology transfer service providers should co-exist in the UK, then the DTI will have to think more carefully how to structure the Business Links and their role to achieve this.

In our society—where information is available in every small city and, within a very short time will be available on every desktop in huge quantities, and which is richly served by a great variety of business support specialities—insurance, law, accountancy, export finance, licensing, financial publishing, etc—is there any reason to suppose that the private sector would not adequately structure itself to meet the market demand for technology transfer services?

Friendly Fire/Collateral Damage

So far in this letter I have addressed primarily the public interest. I now would like to touch on my concerns with respect to Pax and its competitors in the private sector.

We private sector companies are not playing on a level playing field. The playing field has been virtually destroyed by the endless manoeuvring of DTI tanks upon it. The DTI's initiatives, programme rollouts and industry-government partnerships are mostly, in our view, ill conceived. With ample public money it is not difficult to take initiatives. I have no doubt that the cause of technology transfer in the UK would have been greatly advanced had it been ignored by the DTI and left to those with a consistent commitment and responsiveness to market requirements—the private sector operators.

If the DTI wishes to take an active part in the promotion of technology transfer in the UK, then its initiatives should:

1. respond only to clear evidence that a genuine demand exists and is not being met by private sector market supply—eg seminars on technology exploitation strategies for post-graduates;
2. be structured to avoid damage to the private sector provision of related services.

Technology transfer facilitation is a relatively small field of economic importance. The DTI's initiatives, with undoubted good intentions and good-will, have inhibited the growth of a much needed market-sensitive private sector service in the UK. This "friendly fire" has caused significant, if unquantifiable, collateral damage to our company, its shareholders and to its ability to offer technology transfer services on the scale UK plc could have used. Many other private sector technology transfer companies have had to withdraw from the market.

Conclusions

Innovation in the UK could be improved greatly if more medium sized established companies had better trained and motivated scientists and technicians. Improved supply from the universities would be a very positive contribution. The DTI might support "commercial awareness" programs for post-graduates.

The DTI no doubt wants to be seen to be "doing something". It will be more productive if, in its initiatives, it gives higher priority to avoiding unnecessary damage to private sector technology activities and services.

The market itself will be far more cost effective and sensitive than the DTI can be, in meeting almost all UK demands for technology transfer services.

Mr John D. Emanuel, Managing Director

Letter and Memorandum from the Royal Academy of Engineering

I am pleased to enclose The Academy's contribution to the Committee's enquiry into the Innovation-Exploitation Barrier. This evidence comprises a collation of personal views from Fellows of The Royal Academy of Engineering. It cannot reflect the views of all contributing Fellows but it may be considered as being representative.

If The Academy can be of any further assistance, please do not hesitate to contact me.

The Innovation-Exploitation barrier is a subject which, more than most, concerns many of our Fellows in their daily lives. Inevitably, our collated response cannot do full justice to the strongly held views of many Fellows. However, I am sure that the Committee would find it helpful to invite supplementary oral evidence from The Academy and I would be happy to arrange this, if required.

John Appleton Esq, Executive Secretary

17 January 1997

EXECUTIVE SUMMARY

Innovation in UK industry is lagging behind many of its international competitors, including the USA and Japan. This poor competitive performance will only change if large companies can be persuaded that it is in their financial interest to innovate. Links between large companies, SMEs and academia in the "Innovation Chain" need to be fully exploited for ideas to be taken from the Science base and translated into products. Emphasis must be placed on market-led research, if innovation is to be improved in the UK.

The inclination of most Government initiatives, including Foresight, towards a focus on SMEs could well be at the expense of larger companies. The manufacturing health of the UK is largely dependent on large companies. There is concern that some of the UK's world class manufacturing companies are looking increasingly overseas for R&D funding. In the longer term this will strengthen the science and technology base outside the UK at the expense of that within it. This could cause much of our high technology to move overseas and, with it, our manufacturing and employment.

Although links with academia are of great importance, much of industry does not regard collaboration with academia as being "commercially innovative". Instead, these links aim at stimulating and transferring into industry new knowledge, improved techniques and good graduates, all of which in time should lead to more innovation in industry. One problem is that academia and industry have two different objectives; respectively, to publish and to develop competitive advantage. Academics are trained and encouraged to be interested in teaching and research, not development and production.

Introduction

Innovation has been usefully defined as the successful commercial exploitation of new ideas. It is equally important to the creation of new products and the increased competitiveness of well established products for exploitation by companies of all sizes.

In the majority of cases successful innovation is incremental and results from identification of the market need and the technological solution in a seamless environment, often internal to the organisation, but also involving academia, research establishments and other companies.

Many of the Committee's questions imply that innovation starts in Universities and, given successful technology transfer, transfers directly into industry and production. In reality the process is not so simple; academia and industry are linked by a complex "Innovation Chain".

1. *What is the current state of innovation in the United Kingdom?*

1.1 The current state of innovation in the UK is improving, although it is still at a lower level than in the US and the Pacific "tiger" economies. More specifically, a minority of UK internationally competitive companies, such as Rolls-Royce and Glaxo-Wellcome, are particularly strong in innovation and the pharmaceuticals, chemicals and medical industries remain innovative. However, there is cause for concern at the current state of innovation in electronics, computing and some areas of engineering. This will have to change if the UK is to maintain and improve international competitiveness, as will the UK business culture, which is driven by short term profit making and not growth, as in the USA, or market share, as in Japan. The UK does appear to be successful when working in small enterprises is concerned; the British motor racing teams are excellent examples of this, where there is close understanding across all members of the team. Problems seem to arise, particularly communication problems, with larger scale enterprises.

1.2 The research expertise of Universities is not fully exploited through links with industry in the "Innovation Chain". A lack of communication between industry and the UK science base has led to much academic research focusing on developing ideas where there is no appropriate UK-based industry to take them to market. There is also concern that support for academic research is being spread too thinly as more universities compete for the same or reducing funds.

1.3 In reality it has been shown that successful innovation requires one unit of research expenditure to be followed by 10 units of technology demonstration and 100 units of product development. Government support is needed for the costs of scale-up projects to demonstrate technology prior to full product launch. In the US, figures suggest that the Government spends roughly 10 times as much on technology demonstrator projects as on research. In the UK, relatively little is spent by the Government in this way with the result that there is a barrier between research and product development.

1.4 It continues to be the case that the UK is good at "invention", but not innovation where the definition requires successful commercial exploitation. The prolonged debate about the UK's ability to pursue innovation successfully reveals a weakness in the country's attitude to the science and engineering base and a culture based more on science than on making and selling products and services. To a considerable extent, innovation is expected to arise from curiosity driven basic research rather than from a consideration of the demands of the market place. In reality a market led product or development is more likely to be successful.

1.5 One factor which influences the UK's ability to be innovative is the availability of well educated and trained engineers and scientists. The recent move to take pharmaceutical and software jobs abroad as a result of insufficient in-country availability is of concern.

2. *How successful have the Department of Trade and Industry (DTI) and other Government departments been with their range of initiatives designed to stimulate innovation?*

2.1 In general, Government initiatives have been marginally successful at raising awareness at a national level; SMART, SPUR and LINK in particular. The Teaching Company Scheme also appears to have had some success. The large number of such initiatives has been criticised as it is believed to have led to confusion and a less effective overall result than might otherwise have been expected. Foresight has improved links between Government, industry and academia, and identified future technologies of importance to the UK, but has not yet improved technical innovation. Successful innovation does, however, require appropriate funding mechanisms in place which encourage industry/academia working at one end of the "Innovation Chain", followed by successful exploitation by industry of new ideas. The current Business Links schemes have potential to support innovation in smaller companies and should be encouraged.

2.2 There is concern that many Government departments seem geared to supporting established low risk companies and are much less aware of the needs and difficulties of young, high-technology "start-ups". This differs from the culture in the US where hi-tech companies have played a major role in developing an advanced technology economy. The DTI must address corporate governance and short-termism as a first priority. The DTI support for inward investment seems to have been of greatest benefit.

3. *How successful in terms of product or process innovation and other exploitable outcomes are initiatives which encourage collaboration between industry and academia?*

3.1 Much of industry still does not regard collaboration with academia as being "commercially innovative". Instead, these links aim at stimulating and transferring into industry new knowledge, improved techniques and good graduates; all of which in time should lead to more innovation in industry. Industrial links with academia through "CASE-awards" help to strengthen relations; these links are regarded by industry as a means to fund basic research in valuable areas.

3.2 Innovation can be considered as taking place in an interactive, iterative way, often driven by industry with appropriate knowledge gained from a wide variety of sources. This interactive model suggests that one of the key enablers is access to these different sources of knowledge and the realisation that such knowledge is relevant to the issue at hand. Collaborative research, and schemes such as the Teaching Company Scheme are therefore especially effective in that they develop strong personal contacts. There are other important sources of technology which should be considered as well as academia. In particular, intermediate organisations such as Research and Technology Organisations and Government laboratories, whether public or recently privatised, are substantial resources. Many of these are specifically directed to serving industry and have already demonstrated their commercial viability in doing so.

3.3 It must be borne in mind that the product cycle in the industrial sector is very long, and hence the commercial benefits from industry-academia links are subject to a long and significant time lag. The long product cycle means that high investments are needed to launch major product ranges and small companies find it difficult to achieve this. Such companies are therefore likely to fail unless they team with or are taken over by a larger company able to make the necessary investment.

3.4 There is concern that setting up collaborations between industry and academia is time consuming and that obtaining grant funding is too difficult. Seeking direct links with industry places a considerable additional burden on academia as many HEIs are not organised to deal directly and efficiently in this way. SMEs face a similar problem and as a result the majority of SMEs still have no contact with universities.

3.5 Although the initiatives aimed at improving industry-academia links appear to be fairly successful, there are too many of them to be efficient, each with different rules and requirements. In the past many have not been industry led, such as the IRCs, so industry is not fully engaged with much of the work carried out with Government funds. The strong focus of these schemes on SMEs is often at the expense of the larger companies. It has been suggested that there should be a matching of technical resources with SMEs acting as sub-contractors in areas where they have specialist knowledge. Some of the world-class manufacturing companies in the UK are having to look increasingly overseas for R&D funding. In the longer term, although this will enable the companies involved to thrive, it will also strengthen the science and technology base outside the UK rather than within it, and will increasingly move overseas our high technology and, with it, the consequent manufacturing and employment opportunities.

3.6 One problem which needs to be resolved at the outset is that the two sides of the activity have significantly different objectives; to publish and to develop competitive advantage. Academics are trained and motivated to be interested in teaching and research, not development and production. This is a fundamental issue which needs to be addressed.

4. *Does financing need to be improved for technology-based small firms during their crucial start-up and early development phases?*

4.1 There is a need for improved financing for such companies. The level of understanding of the whole evolution of small hi-tech companies still appears to be very low. Unless the innovation on a small scale "niche" development, it is increasingly difficult for smaller companies to take innovations through to

international markets. The City generally fails to support technology-based companies, particularly small ones. There is perhaps a need for a government-supported "Bank for Innovation and Industrial Development", targeted at SMEs. Most venture capital appears to go into management buy-outs and buy-ins rather than the funding of new products.

4.2 Government aid for the purchase of IPR for SMEs is one area where assistance could have an impact. This is already done for large and small companies throughout Asia, one of their keys to success. Help given to companies to buy developed products would increase a company's chances of survival and rapidly increase growth rate. Increased export assistance, including travel support could also be given. This would provide immediate assistance in the form of increased sales of newly innovative products. Financial assistance in setting up agents could help the success of innovation.

4.3 In Taiwan, "incubator units" are created for new hi-tech companies to start up in. These are on science parks where there are government funded research and development centres which provide active help with equipment and expertise. One problem is that small companies do not understand how to judge risks in new product introduction, and as a result are seen as high risk financial investments.

4.4. This is not solely a problem among small high-technology companies. The general level of investment in innovation by the larger UK companies is also significantly less than their world-wide competitors. This results in reduced rate of growth of these companies and of the UK economy as a whole. The underlying cause is the mismatch between long-term high risk and short-term quick return on money from the financial system. There is a danger that the relative importance of small companies in creating future GDP will be over emphasised.

5. *What other support systems could be introduced to ensure that the maximum advantage is taken of innovative ideas that originate with individuals or, for example, in academia?*

5.1 Any system introduced for this purpose should enable an academic to have access to the organisation that might market or apply the outcome of the work, throughout the time the research is in progress. Existing research council funding mechanisms rely too much on technology push and do not engage companies sufficiently at a very early stage. Foresight should be used to encourage links between academia and smaller companies. More effective networking is needed between researchers and practitioners from all sides of industry. The role of technology in economic development is little understood.

5.2 The privatisation of British Technology Group has led to short-termism within the company, to the detriment of the exploitation of innovative ideas that originate in academia. There would be some benefit from introducing something like the "old BTG", with its special links with the Research Councils and Government laboratories, albeit changed to correct for previous inadequacies. This would aim to take advantage of the substantial resource for invention existing in the UK. One of the most difficult problems to overcome is the need to increase awareness of the various means of funding which already exist. A corresponding need for awareness of ideas requiring funding by finance providers is also required.

5.3 Support systems emerging from Foresight, such as the Foresight Challenge, will help to ensure that maximum advantage is taken of new innovative ideas originating from academia. Overseas, notably in the USA and Japan, national programmes are used as the focal point for technology generation and exploitation. By involving the whole supply chain in these programmes, it is possible to involve small, medium and large companies in a single programme. One problem is that the technology chain is not paralleled by a matched funding chain.

5.4 Greater academic weighting needs to be given to patenting the results of research. Many academics are not fully aware of the importance of developing intellectual property to protect and exploit their innovation. To remedy this situation it might be appropriate to establish an office or agency to monitor publications and draw the innovators' attention to the commercial steps necessary for exploitation. Promising cases could be followed by encouraging the establishment of development contracts with companies capable of manufacturing the product or implementing the process. Funding could also be made available to release individuals from teaching and other duties to exploit particularly good ideas.

5.5 The Technology Foresight Construction Panel has, in common with others, identified the need for more effective networking between research and practitioners from all sides of industry. The importance of learning networks was particularly emphasised. It has been suggested that a scheme is needed to encourage the formation of such networks between industry, intermediate organisations like research and technology organisations, and academia.

5.6 Positive tax incentives for company funding of research and technology transfer activities should be introduced. Delayed depreciation on capital expenditure for research equipment and manufacturing plant should also be considered.

6. *Is there institutional based inertia towards the funding of technology-based small companies? If so, to what extent may this be due to financiers' unfamiliarity with science and technology concepts and what should be done to address this?*

6.1 There is widespread concern at investors apparent interest only in short-term projects. Initiatives to encourage long-term support (5-10 years is usually needed to bring innovations to market) are essential. This mismatch between the financial community's demand for rates of return and the time scale is fundamental. To some extent this is due to financiers' unfamiliarity with science and technology concepts. One solution to this would be for the Government to encourage the use of external advisors, with technological expertise, to act as facilitators in support of venture capital decision making on behalf of both parties in the transaction. Small companies should also be encouraged to get early business advice so that they can explain their objectives in business terms, and to recruit at least one scientist/engineer with an MBA or other business qualification. Companies must have a credible business plan in order to secure funding from investors. Alliances of small companies with larger companies should be encouraged as this reduces the risk for all.

7. *The Committee recommended tax credits for research and development in our previous enquiry. Would this still be an effective way of fostering innovation and how should they be introduced to ensure that they are roughly cost-neutral?*

7.1 Tax credits should be introduced for research and development. They are an effective way of fostering innovation, as has already been shown in the US. The extra funds retained by R&D based industry as a result would be used for additional R & S on projects they could not otherwise afford. The credits would also provide encouragement for financially-driven boards to look more kindly on R&D.

7.2 Tax credits would be cash-neutral, if regarded as long-term investments leading to greater commercial success resulting in an overall increased contribution to taxes. It is important that the Government invests in the long-term prosperity of UK industry. If the costs of the tax credits were to be recovered from companies in other ways, it is unlikely that many companies would look on them favourably. The UK's poor competitive performance will only improve if large companies in particular can be persuaded that it is in their financial interest to innovate. Large companies should be encouraged to spend as much as their competitors. One problem that arises, however, is the definition of R&D. This could be defined as "development projects", which generate no income and are not capital projects in nature.

7.3 Alternatives to tax credits are capital allowances or, as has been proposed by the Construction Industry Council and others, a grant/levy arrangement, similar to the grant/levy arrangement for training in the construction industry, where the levy was collected on payroll costs. Grants could be made to cover expenditure on qualifying research, restricted to research of general benefit rather than confidential to the company concerned. This scheme would specifically promote research of general benefit to a whole industry sector, the construction sector being a particular advocate of this approach. Tax credits should also be made available for support given by industry to academia.

8. *How has the Technology Foresight exercise influenced the availability of development funds for innovative ideas that were not given short-term high priority status?*

8.1 It is too early for any influence of Foresight on innovation to be seen. Any system operating in the R&D area needs to have a track record longer than one economic cycle (for example, data gathered over a period of 10 years) if any reliable conclusions are to be drawn. It is likely that Foresight will have some influence, in particular by bringing university research topics funded by the Research Councils more in line with industrial needs.

8.2 Foresight has improved technical cohesion in the UK, but the people involved are unlikely to be those making investment decisions. It does not appear to have focused much on new business opportunities. There is a real requirement to ensure that the Government Science, Engineering and Technology budget is allocated and prioritised in a way which will lead to adequate support being made available to all technologies identified as critical under the Foresight initiative, including those of lesser priority. New money is needed for Foresight, rather than a reallocation of existing funds. In particular Foresight has not released new funding for technology demonstration. Schemes, such as the Society of British Aerospace Companies (SBAC) "Foresight Action" programme, would greatly assist in revitalising the status of technology demonstrator programmes if they were given Government support and funding.

8.2 One cause for concern is that the larger companies involved in Foresight, by virtue of their larger horsepower, are carrying the main programmes forward and therefore shaping them to their need, instead of to the needs of SMEs. It also takes time and money to be successful in winning any HMG or EC grant support, often more than the grant is worth. Unless the mechanisms and associated costs can be reduced, SMEs are increasingly likely to ignore this potential source of funds.

9. *Has the tax-relief introduced in 1992–93 for individuals' expenditure on vocational training had any impact on the status of continuing professional development, in particular for employees in small firms?*

9.1 It does not appear that this tax-relief has had any impact. It is likely that until it becomes *de rigeur* for large companies to give quality continuing professional development to their employees, SMEs will not do so. In reality, it is the institutions and their attitudes to membership coupled with a certificate to practice, as for example solicitors, which will dictate whether an individual and then a firm will support vocational training. There is a great need for companies to benchmark themselves against international competition.

Letter from the Royal Society for the encouragement of Arts, Manufactures and Commerce (RSA)

Following our telephone conversation at the end of January, I have pleasure in enclosing copies of reports which are relevant to the above inquiry (*not printed*). I have had to delay despatch a few days as one of the reports has only just arrived from the printers, but this should still comfortably meet the cut-off date for evidence which you accepted as being 18 February.

Analysis and insights have been developed considerably since the RSA sponsored Industry Year in 1986 and the results are reflected in these reports. The inadequate UK levels of innovation and related underperformance in education, skills and the development of new science and technology based products are seen as symptoms of a systemic problem. By their nature such 'systems' problems cannot be solved by conventional or independant single-issue 'fixes'. With this insight the concept that there are 'barriers' (which can be shifted) on a UK route which is otherwise similar to those available in competitor countries can be misleading. More helpful is the perception that we need to change the topography over which the routes available to the UK entrepreneur, scientist and industrialist have been constructed. These are narrow, winding, slow, frequently difficult and sometimes financially dangerous. They do not always lead to objectives of benefit to the real economy, even if personally rewarding.

The RSA's report of the five seminars and three lectures in 1993, published in 1995 as part of the ongoing Wealth Creation and the Economy series, gives a broad background to the development of these ideas, which were developed further in the October 1996 seminar as reported in "Re-assessing the Context of Manufacturing Success". An approach on similar lines, co-ordinated with this work, is given in "Making Sense of Creating Wealth" which being a single author document is able to explore and develop several aspects somewhat further.

All these reports have an "Executive Summary". We hope you will find them helpful. We will be pleased to give verbal evidence if this is thought to be appropriate.

Professor Ivan Yates CBE, Chairman, Manufacturing Initiative

5 February 1997

Memorandum by The Royal Society of Edinburgh

The Royal Society of Edinburgh has, in conjunction with Scottish Enterprise, carried out an enquiry into issues relating to the commercial realisation of research activities with particular reference to the HEIs and grant funded Institutions in Scotland. The results of the extensive research programme, which evaluated not only activities in Scotland but also analysed successful activities in the field in USA and throughout Europe, have been published in a report (Ref 1).

Following the report and wide-ranging consultation with interested parties, a strategy was developed to assist in the process of commercialising Scotland's Science and Technology. This strategy is contained in a second report entitled "Technology Ventures" (Ref 2). The Royal Society of Edinburgh has established a working party under the chairmanship of one of its Vice-Presidents to oversee the activities of the Society in support of the implementation of the strategy.

This response to the Sub-Committee from the Royal Society of Edinburgh is given in the context of the above study and with particular reference to the situation in Scotland.

1. *Current State of innovation in the UK*

It is pertinent to recognise that innovation takes place in both industry and academia. Innovation in Universities and Research Institutes is usually equated with research while in industry the term is more widely interpreted. In Scotland, the national Research Assessment Exercise of Universities rates 53 science departments highly, which is significantly above the national average per head of population. Further, the number of peer-reviewed publications per head of population in Scotland ranks third in the world.

It is noted, however, that government funding sources for research (as distinct from charitable trusts and industry which contribute a significant percentage of the funds available to Universities and Research establishments in Scotland) discourage near market research. The timescale for exploitation of innovation arising from government funded research can therefore be lengthy.

Due partly to the relatively low level of industrial research and development in Scotland, leading research in Scotland is often licensed to foreign multinationals. The Technology Ventures Strategy (Ref 2) is aimed at increasing the economic benefit to the UK by encouraging exploitation of research in Scotland.

Innovation in industry relates both to process and product development. With some notable exceptions, most of the large high technology industry in Scotland is concerned only with manufacture of products with limited opportunity for innovation. This is a result of the financial incentives targeted at creating jobs through inward investment rather than encouraging product development and ownership.

There are also a number of highly innovative indigenous companies at early stages of their development. In spite of this the general level of innovation in SMEs in many sectors is low. Often initiatives by local and national economic development bodies have been to promote innovation in such SMEs to support the supply chain to larger technology based manufacturing companies. The benefit of directing support to promoting innovation in SMEs with leading edge technologies is not fully appreciated.

2. *Department of Trade and Industry Role*

The DTI schemes SMART and SPUR are generally recognised as being very helpful to small companies at the early stages of their development but the process is often viewed as too bureaucratic and the amount of money involved too restricted.

Regional Selective Assistance is much more significant in value but is effective primarily in introducing foreign multinational manufacturing capability. Industry would welcome a broadening of the remit of this funding to assist with Scottish-based product development and innovation in both multinational and indigenous companies.

The Teaching Company Scheme can be useful in transferring technology and training new graduates for industry but incompatibilities exist between the requirements of industry and academia. Companies which recruit graduates are more likely to be involved in innovation.

The partnership between Industry, Higher Education and the government has been shown in other regional economies to produce successful results and should be developed further in the UK.

3. The enquiry (Ref 1) found that there is a higher proportion of Scottish academic scientists working with industry than in the USA but that less of their work is related to entrepreneurial activities. Most is related to training. There is significant evidence from abroad that initiatives such as CONNECT, MIT Enterprise Forum, scouting programmes and interface organisations play an important part in commercial exploitation of innovations from Universities. These mechanisms are not widely available in the UK.

4. In Scotland, most spin out companies have found difficulty raising finance and the majority of small companies have problems funding research and product development. The business angel and venture capital market is less prominent in the UK than the USA. The government programmes SPUR and SMART are valuable sources of finance for small companies. A comparison with the roughly equivalent SBIR programme in the USA shows it to be more effective than the UK schemes because the level of funding is greater and 100 per cent of the project costs can be provided.

5. Following analysis of the problem in Scotland, support mechanisms which have been introduced include: Scottish Business Forum based on the MIT Enterprise Forum; CONNECT programme modelled on the successful San Diego experience; an equity partnership fund targeted at the small company early stage funding and various scouting activities. The Royal Society of Edinburgh is running a series of seminars bridging the gap between local industry and academia including both exploitation of existing research and developing better links for Foresight programmes.

Recognition should be given by the funding bodies of work done by University Departments to develop and commercialise their ideas. The current peer review system focuses on publishable "good science" to the virtual exclusion of exploitation.

6. The presence or not of inertia in funding mechanisms is viewed differently between the potential recipients and the sources of finance. Better understanding on both sides is the key to improving the situation.

As the cost of managing small investments is proportionately high, some incentive through the tax system could be given to encourage a percentage of funds to be invested in unquoted, non-management buy out new business.

The existence, as in the USA, of a secondary market (AIM) aimed at smaller high technology companies which provides an exit route for early stage financiers has gone a long way to releasing funds for high technology companies which need considerable investment finance to reach self sufficiency.

7. The use of tax credits is considered in the USA as a major contribution to increasing R&D in small companies. As early stage high technology companies operate at a loss, tax credits must be realisable in cash terms either from the Treasury or by being traded with profitable companies.

8. The Technology Foresight Exercise is targeted at longer-term research goals and is welcomed for giving more commercial direction to some of the research effort. The development potential of the results has yet to emerge but we have no reason to believe that it will not.

9. The availablity of tax relief for individual expenditure on vocational training is not widely known about and does not appear to be utilised significantly.

Ref 1: Commercialisation Enquiry: Final Research Report 1996—ISBN 0 905574 19 2.

Ref 2: Technology Ventures 1996—ISBN 0 905574 19 2.

Memorandum by the Save British Science Society

On Saturday 8 February a Symposium, "Bridging the Gap", was held near Oxford. It was organised by SBS with the help of the Innovation Unit of DTI and the Oxford Trust and with financial sponsorship from the DTI and NatWest.

The "Development Gap"—a failure to invest adequately in the R&D necessary to carry new ideas and technology forward into new marketable products and processes—is a fundamental weakness across British industry. However the Symposium concentrated on the difficulties of new, small, high-tech companies.

The "Gap" in mind at the Symposium was that facing a would-be high-tech entrepreneur looking for seed-corn and early-stage financing to form a company, demonstrate technical and market potential, and reach the shores of the classical Venture Capital or Equity Markets with favourable expectations of success.

The programme focused on three themes: the rules of Incubators; Sources of Finance; and the Public/Private Partnership. These are not independent, and there are many common threads running through them—for example the need for technical brilliance to be coupled with professional standards of management. The first two are fairly clear as topics, the title of the third was taken from the Bank of England report "The Financing of Technology-Based Small Firms" which observes: *"Improving the financing of technology-based firms requires a partnership between public and private sectors, based on a fair distribution of both risks and rewards".*

A report on the Symposium, which will contain the introductory talks and reports on three Working Groups, is in preparation. This note expressing SBS views on the topic draws on an incomplete summary of suggestions and other points made during the Symposium.

1. *Incubators*

Incubators assist people with ideas and entrepreneurial drive by the creation of an environment of young businesses with common needs sharing access to a variety of support functions. These can include advice and help in the management of a company and the formation of management teams.

The important role of Incubators as a focus of local networking was stressed at the meeting. Links with local sources of advice and finance, local companies, universities and colleges, business schools and BusinessTecs, public sector research establishments etc, help the work of the Incubator and contribute to developing an entrepreneurial climate throughout the local community.

Universities can be outstandingly successful as specialist, first-stage "incubators". This potential for "spin-out" should be encouraged in both universities and public sector research establishments (PSREs).

2. *Finance*

There is clear evidence of "market failure" in the provision of capital for start-up finance, seed-corn and early growth, in the high-tech sector—an effect sometimes referred to as the "hairdresser vs the PhD" problem.

The banks do not regard risk capital as their proper business. For the sources of classical Venture Capital (VC) the entry costs are disproportionately high compared to the returns expected on the relatively small sums involved, in the range of £100,000 to £1 million.

Two developments are leading to an improvement. The banks, as illustrated by NatWest, are offering "packaged" help; Managers are being trained to have a better understanding of the needs and of the difficulties faced by technology[11] based companies and, rather than turning the entrepreneur away, can offer advice and a package which may include a loan, assistance with applications for grants and access to sources of private equity finance.

More significantly, there is a growing band of specialist VC firms bringing technological understanding to the assessment of risk and willing to take a role in management. A rising contribution to start-up and seed-corn financing is being made by already succesful high-tech entrepreneurs turning into Business Angels. The importance of these "serial entrepreneurs" was stressed at the meeting, with the suggestion that forming associations—for example of "Incubator alumni" and groups specialising in particular technology sectors—would help them to work "in parallel" and spread the risks.

[11]A banker strongly advised against use of the term "high-tech", which induces panic in most Bank Managers!

Effective steps helping high-tech entrepreneurs to success and later conversion to specialist Business Angels can have a powerful gearing effect. This seems a most promising way to achieve the essential build-up of technologically-informed sources of seed-corn and early stage finance necessary to help more companies to "bridge the gap".

Funding has not only to be accessible, decisions must be made quickly: the speed of technological advance is accelerating and product life cycles shortening, to as little as three years. Opportunities therefore must *"be taken on the flood . . . or lose our ventures."* This is where the specialist Angels, offering the possibility of a quicker response, have a particular role to play.

For their part, the entrepreneurs seeking finance need to recognise the importance of a sound management team in building confidence that the money, if forthcoming, will be used to good effect. A problem often arises when the salary necessary to attract a top-quality, appropriately experienced CEO may be three or more times that which the entrepreneur takes.

3. *The Public/Private Partnership*

The small, high-tech business sector is a part of the economy capable of driving the fastest growth in employment, both through filling its direct needs and via the new demands generated for suppliers. Such companies also typically show high export ratios for their products. Public investment which aids growth in this sector, through a fair sharing of risks and rewards, therefore has a potentially tremendous gearing effect, aiding the economy generally and helping to reduce public expenditure overall.

Governments in other countries operate a variety of measures which help to moderate the effects of market failure and assist nascent entrepreneurs across the bridge to company viability.

SBS strongly recommends Government to:

— develop a coherent, overall approach to the needs of new high-tech companies; and

— undertake a serious study of the methods used in other countries, with a view to adapting the most appropriate ones for the UK.

Several ways in which the launch and growth of small high-tech companies could be helped, or not directly impeded, were suggested at the Symposium.

3.1 *Taxation etc*

Large firms can offset losses in one sector against profits elsewhere; small firms have no corresponding flexibility and should be able to roll forward their losses in early years.

The reinvestment of any profit in the early years is vital to the continued research and development necessary for survival and growth; profits invested for use in this way should not be subject to tax.

Small Venture Capital Trusts are penalised by the high costs of the required listing on the London Stock Exchange[12]. These costs should be subsidised or at least made allowable against tax.

An entrepeneur should be allowed CGT relief for gains invested in his own company.

Enterprise Investment Scheme (EIS). Entrepreneurs should be allowed to invest in their own business.

3.2 *Direct Support*

SMART and SPUR. Expansion of these schemes was very strongly supported. While not available at the very early stage (of reliance on "family and friends") they make a very important contribution at the next stage both directly and as an effective assurance of feasibility and quality helping to lever capital from private sources.

Loan Guarantee Scheme. One of the most useful Government schemes, it should be much more widely used but is not well known[13].

Small Business Investment Companies (SBIC) and Small Business Innovative Research (SBIR). These American schemes for the promotion of small companies were singled out as suggestions for adaptation by the UK Government. The first is now able to provide funds through equity as well as dept. The introduction of an SBIR-like scheme[14] in the UK would be a great stimulus to many high-tech small companies at no cost to the exchequer.

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[12]An example given was about £150,000 for a £2.5 million fund.

[13]Some Banks were said to deny its existence!

[14]The SBIR scheme requires Federal Agencies with large R&D budgets to place R&D contracts worth at least 2 per cent of their total R&D spend with small companies; this is entirely cost neutral, yet has an enormous, positive impact on the high-tech small business sector.

3.3 *Other Suggestions*

Incubators. The important role of Incubators in nurturing the "virtuous circle" of successful entrepreneurs who may in turn be able to "seed" new ventures, justifies consideration of measures to assist their creation, such as by matching locally raised finance.

Entrepreneurship. Grants should be available for scientists and engineers to gain experience of an entrepreneurial environment while doing research for a higher degree in association with a small high-tech company[15].

Venture Capital Trusts. These are not contributing effectively to the formation of small high-tech companies. Special incentives are required to stimulate the growth of smaller, specialist Venture Capital funds dedicated to start-up and early growth.

Licensed Seed Capital Funds. In this scheme suggested as the Symposium an entrepreneur with demonstrated success would be licenced to run a Seed Capital Fund operating in the sector of his or her own business experience. 25 per cent of the fund would be the business-person's own money, the rest from Government partly as equity and the balance as a low interest loan. The entrepreneur would have to provide advice to each investee firm, advice which would be of high quality since the risks are shared.

Mutual Guarantee Scheme. It is proposed that local groups of investors working together should receive help/incentives to finance a fund to cover losses. Similar schemes are common on the Continent.

4. *Spin-out from Universities and PSREs*

Universities. Universities can play a very effective role—in effect as first-stage Incubators—by providing a stable operating base and technical support for the development of an idea which may eventually become the basis for the formation of a Company.

Several very successful high-tech firms started out in this way, as a result of local, Departmental level, initiatives. These companies would not find conditions favourable to success today. The extreme pressure on resources—money and staff—now leaves little or no margin of flexibility for the exercise of such local discretion.

The high potential for spin-out is now widely understood in universities and should be recognised as one very important justification for the restoration of an adequate level of HEFC funding giving room for local enterprise to flourish. The increasingly tight centralised control of resources, through allocation of RC funds to specific functions, is a strong restraint on such initiatives.

PSREs. The same potential for spin-out exists for PSREs and it should be strongly encouraged. Tight direction of research programmes, especially for those in "Agency" status, should not exclude the flexibility necessary to allow staff the time and resources. Staff in such establishments in France are, under certain conditions, entitled to financial assistance on leaving to set up a Company, and re-employment should the venture fail.

14 February 1997

Memorandum by Scottish Enterprise

Introduction

1. The barriers constraining innovation and the exploitation of science and technology in the UK are many and varied. To a greater or lesser extent they differ between industrial sectors and technologies, by company size, whether or not innovation is through a start-up company or a more mature business, by geographic location and by the source of the innovation (eg corporate laboratory or an academic institution). However, from your letter of 28 November 1996, we understand your Committee wishes to focus on:

— The extent to which the United Kingdom suffers from an inability to exploit its own developments in science and technology (especially that produced in the universities).

— What can be done to address this problem with particular reference to the start-up and early development of technology based companies and financing issues.

This evidence draws on Scottish Enterprise's experience to make a number of specific policy suggestions which we believe are worthy of more detailed consideration.

[15]In Germany the government ran a scheme which subsidised the salaries of qualified scientists and engineers employed to perform research and development in small companies. When, after five years, it was ended many of the companies maintained R&D activity.

Background

2. Scottish Enterprise (and its predecessor, the Scottish Development Agency) has a long history of promoting and supporting innovation in Scotland. This includes a variety of business support programmes for innovative existing and start-up companies delivered through the Local Enterprise Companies; pump priming finance for applied R&D centres of excellence, technology transfer mechanisims and incubator facilities in Scottish Universities; provision of science parks; early stage investments for many of Scotland's new and young high tech companies; and sectoral strategies in food, textiles, the IT industries (electronics, software, opto-electronics) and biotechnology.[16] In 1993 the Business Birth Rate Strategy was launched to increase the number of new companies (including high tech companies) set up in Scotland and the number which achieve significant growth.

3. The Birth Rate Strategy identified Scotland's strong science and technology base in the universities and research institutes as a potentially important source of new technology based companies. Following an extensive research programme and process of consultation with key players in the academic, business and financial communities, Scottish Enterprise and the Royal Society of Edinburgh launched Technology Ventures during 1996, a strategy to increase the contribution the science base makes to economic development through its more effective commercial exploitation in Scotland.[17] The following comments draw heavily on this strategy and the supporting research evidence.

Exploiting the Science Base

4. Our research for Technology Ventures confirmed that the Scottish Universities undertake much research which is both academically world class and has actual or potential commercial relevance. It also found that extensive contacts already exist between academia and industry. However, relatively few are concerned with product or process innovation and the research confirmed that opportunities are being missed. Much of our science and technology is exploited by overseas companies. By European standards the number of new high tech companies and academic spin outs is reasonable. However, judged against some of the world's leading high tech regions and universities, there is considerable room for improvement. Our evidence shows that to exploit the science base effectively, more than commercially relevant (or funded) research and academic-industry links are necessary.

What can be done about it?

5. There is no single or simple panacea. Barriers at all stages of the innovation process starting with the selection and nature of basic research, through applied research, prototype and product development to market entry and company growth must be reduced. Consistent and mutually reinforcing initiatives are required in a number of interrelated policy fields including technology foresight, higher education, research, business development, industry strategies and the promotion of entrepreneurship. While government initiatives are important, much must also be done by key players within the academic, business and financial communities. Mechanisms are required to encourage their active participation and co-operation. Technology Ventures sets out an agenda for action under six broad headings which Scottish Enterprise believes would increase innovation and the exploitation of science and technology.

6. *Existing companies.* A number of programmes such as LINK and the Teaching Company Scheme have brought about closer working relationships between academia and larger companies. Less progress has been made on enabling Small and Medium Sized Enterprises (SMEs) to exploit science and technology. Suggested initiatives include:

— Assist SMEs to recruit scientists and technologists. Companies which employ graduate scientists and technologists have more links with academia and have greater internal capacity to exploit science and technology. Small schemes operated by Scottish Enterprise (eg the Scottish Textile Design Scheme) have encouraged SMEs to recruit skilled manpower, improved company competitiveness and enhanced graduates' skills and their access to employment. Germany has made extensive use of recruitment subsidies to strengthen the innovative and technical skills of SMEs.

— Creation of more effective local academic—industry networks. These should improve the two way flow of ideas and information between industry and academia and draw in the financial and business services community. A model worth further investigation (and currently being implemented in Scotland) is CONNECT from the University of California at San Diego. It is run from the university with a private sector board and funding. It supports the area's technology based industries by creating networking opportunities linking academic researchers and local companies; providing business support services both to companies and academics wishing to commercialise

[16]For a more detailed description of these activities see Scottish Enterprises's evidence to the House of Lords Select Committee on Science and Technology, "International Investment in UK Science". HL Paper 36-II Session 1993–94, p 217.

[17]Scottish Enterprise and The Royal Society of Edinburgh, "Technology Ventures; Commercialising Scotland's Science and Technology" 1996. The supporting research is reported in "Commercialisation Enquiry, Final Research Report" 1996. Available from The Royal Society of Edinburgh.

their research; creating mechanism to help companies raise finance and by connecting local companies to the university's global networks.

— Scouting and Technology Development Services. Within Scotland there is no formal mechanism to place academic technology in SMEs or to find science and technology to meet the needs of SMEs. In Denmark, the Danish Technology Institute provides such a service. It brokers partnerships between the sources of technology (often a university) and SMEs which may result in formal licensing deals. It also undertakes (for a fee) technology development which is often required before an SME can take forward academic research.

— Programmes equivalent to the American Small Business Innovation and Research SBIR) and Small Business Technology Transfer (STTR) programmes to finance R&D within SMEs and enable them to work more closely with academia. (These programmes are discussed further below).

The successful exploitation of science and technology is much more than a technical issue. It requires appropriate commercial expertise and often involves managerial and other forms of business innovation. Scottish Enterprise is aware of at least two issues requiring consideration. First, younger growth orientated companies perceive the recruitment of appropriate management as a serious constraint. Second, these companies often find entering non-UK markets a particular problem.

7. *Spin Outs.* Compared to the US, fewer Scottish and UK academics perceive spin outs as an effective route for the commercial exploitation of science and technology. In addition to the difficulty of financing spin outs, conflicts of interest with their academic position, HEI rules and regulations and difficulties over the ownership of intellectual property are seen as major constraints. However, spin outs can be an effective, and sometimes the only available, route for exploitation. To achieve more successes, a significant increase in the number of spin outs is required. To achieve this, initiatives include:

— Education and Role Models. The spin out route is not well understood and many have been poorly financed, structured and managed with inadequate business strategies and ineffective ongoing links with their parent academic institution. Increased awareness and understanding could be achieved through the widespread introduction of entrepreneurship courses and course modules within higher education. Post graduate scientists and technologists and contract research staff are an important "target market".

— Formal Start-Up Programmes for technology based businesses. For example, the TOPS programme at the University of Twente offers up to 30 places each year for graduates wishing to start a company. They become "research assistants" with a start up loan of £12,000, access to university laboratories, supervision to develop the technology and space in the university's incubator. A similar programme has been launched for young graduates working in industry but wishing, with the support of their employer, to start a new company. Similar programmes have been developed elsewhere. For example, Denmark uses entrepreneurial stipends to promote technology based companies.

— Incubators. These need to be more than the provision of accommodation. Some of the most effective US examples offer (often informal) business support and advice, are an integral part of the academic community and provide links into local high tech business networks.

Institutions such as CONNECT could promote and support spin outs while universities could do more to recognise and resolve conflicts of interest. In Scotland, academic staff often become the CEO of spin outs. In the US, external management is more frequently brought in with the academic perhaps becoming a non-executive research director. Improving the way in which spin outs are set up and managed would reduce conflicts of interest and give them a better chance of raising finance and being commercially successful.

8. *A Stronger Corporate Base.* Within the Scottish context there are relatively few companies with the ability to innovate through the exploitation of science and technology. The number of such companies can be increased by initiatives which promote and assist spin outs (and technology based new starts in general) and which enable SMEs to recruit science and technology graduates. In addition, Scottish Enterprise is exploring ways in which more inward investment with research, design and development responsibilities can be attracted to Scotland. In this context, consideration should be given to whether regional policy incentives (eg Selective Regional Assistance) could be made more effective.

9. *Academic Environment.* Innovation is the responsibility of industry. However, change within the academic environment is also necessary. Both individuals and institutions should be given greater incentives and rewards for getting their research commercially exploited within the UK and exploitation should become an integral part of the research process (rather than being seen as an "add on" which is somebody else's responsibility). Specific suggestions include:

— Universities incorporate a commitment to the exploitation of science and technology in their mission statement. Commitment could be reflected in, for example, promotion criteria. A number of leading American Universities see their role as teaching, research and community service. In some cases this includes an explicit concern to support local industry and to promote economic development.

— Universities could (and financial incentives might be provided to encourage them to) recruit more staff with industrial experience. Our research found that staff with industrial experience are more

involved with industry and the exploitation of science and technology. Similarly incentives might be designed to encourage staff secondments to industry.

— Introduce course modules on exploiting science and technology into a wide range of science and technology courses. The University of Texas at Austin has, for example, recently introduced a PhD programme on commercialising science and technology. Scottish Enterprise has provided pump priming finance for entrepreneurship courses in Scotland. A similar possibility for courses on exploiting science and technology is being considered. However, these subjects should be part of the mainstream funding of Higher Education.

Universities and research institutes need to derive positive benefits from exploiting their science and technology rather than getting involved under duress or simply to make money. Few universities make large amounts of money from selling their intellectual property and a concern to generate short term income may not lead to its effective exploitation within the UK. Some of the more successful US universities see the rewards as employment opportunities for their students, future research contracts and sponsored professorships. The criteria used to evaluate university performance and to allocate resources (eg The Research Assessment Exercise) should provide the necessary incentives and rewards.

10. *Institutional Infrastructure.* At least within Scotland, there is a need to strengthen the institutional infrastructure which bridges the academic—industry technology gap. Scottish Enterprise has sought to do this through pump priming finance for, for example, the Microelectronics and Imaging Centre, the National Microelectronics Institute and the Edinburgh Parallel Processing Centre. Nevertheless, a wide ranging review of how this might be most effectively achieved is required. This should draw on overseas models such as the German Fraunhofer and Steinbeis and US models such as the North Carolina Biotechnology Center, the Microelectronic and Computer Networking Centre and the NSF Engineering Research Centres. In addition, compared to the world's best University Technology Licensing Offices, most Scottish Industrial Liaison Offices are small scale, under-resourced and not adequately integrated into local high tech and financial networks. The focus needs to be on exploiting and not simply protecting intellectual property.

11. *Access to Finance.* Our experience and research findings[18] are consistent with those of the Bank of England report "The Financing of Technology Based Small Firms" confirming that access to appropriate finance is a constraint. In particular, there is room for improvement in seed corn and early stage funding for start-ups and the financing of applied R&D and product development in both start-ups and more established SMEs. A comparison between Scotland and Massachusetts found:

— Technology orientated venture capital and business angels are much more numerous in Massachusetts and, importantly, willing to invest at an earlier stage in both the company development and innovation process. For example, there is greater willingness to fund "pre-start" applied R&D and prototype development. In Scotland, the majority of investors only consider investments once these have been completed.

— Greater public sector support through, for example, the SBIC and SBIR programmes and through State Government initiatives. For example, the Massachusetts Technology Development Corporation (MTDC) is a revolving fund initially capitalised by the State Government investing in early stage high tech companies. It works closely with private sector venture capital. There is little concern that it may displace the private sector. Rather it is seen as stimulating deal flow and developing the market.

In comparison to Scotland, Massachusetts venture capital companies see the job as "business development" rather than financial engineering and deal making. Indeed, in the US venture capital is classified as a business rather than financial service. The research also confirmed that US investors are more comfortable with technology based proposals. In part, this is because more staff have entrepreneurial experience and a technological background than in the UK.

12. Investment Strategies also differ. Early stage US investors are more likely to invest straight equity and seek a return through capital gains while Scottish investors are more likely to want an income flow from the company. The US approach better meets the needs of new and young technology based companies. To a considerable extent the difference reflects the existence of the NASDAQ market in the US. By offering early stage investors an exit route and means of realising capital gains, it reconciles the company's need for long term, patient money with the investor's desire for greater liquidity and shorter term investments. It also, of course, enables companies to raise further equity finance.

13. Recognising the crucial role such a market plays, Scottish Enterprise worked with the Stock Exchange to develop and launch the AIM market. If successful, this should create a market similar to NASDAQ. Scottish Enterprise is currently exploring ways in which companies can be more effectively prepared for the market and the cost of raising finance on AIM can be reduced. To improve the supply of finance to technology based new small companies, it is essential everything possible is done to make AIM a success.

14. Improvements on the demand side would also increase access to finance. Initiatives which stimulate the number of high tech start-ups will increase deal flow and the opportunities for the financial community to make an acceptable return. In addition, many proposals are not well structured or overvalue intellectual

[18]See chapter 20 in Commercialisation Enquiry, Final Research Report.

property. For example, in comparison to US practice, UK universities sometimes want a significantly higher equity stake in spin outs in return for the intellectual property. They may also wish to be more involved in the company's management. This leaves little room for external investors and generates a concern that the company will not be well managed or fully commercial. A more realistic understanding of what can be expected of external investors is required as is an acceptance that a small share of a successful enterprise is worth more than a large share of a failed one. As suggested in the Bank of England report, role models and education of entrepreneurs and investors could improve access to finance.

15. More generally, Scottish Enterprise endorses the recommendations in the Bank's report including the proposal to examine the SBIC programme. In addition to the Bank's recommendations, we also believe something of a cultural change is required. Our research found, in contrast to the US, that Scottish entrepreneurs see the financial community as the problem while financiers see the entrepreneurs as the problem. Rather than continuing to debate whether or not there is a problem and where the blame lies, all the key players need to accept that access to finance can be continually improved and that they can make a contribution to the process.

16. Scottish Enterprise also welcomes the Bank's recognition that there is a role for the public sector. In specific terms, Scottish Enterprise is exploring ways in which a technology development fund could be set up in Scotland; how a network or club of high tech business angels could be created and is seeking to draw the financial community more fully into business support networks. For example, the financial community is a key player in CONNECT which has now been launched in Edinburgh.

SBIR Programme

17. Funding R&D and product development is both difficult and high risk for SMEs. However, such funding is crucial to innovation. One possible means of providing SMEs with greater access to this type of finance is the introduction of a UK equivalent to the US SBIR programme. Each Ministry with a research budget over $100 million (including the National Science Foundation) allocates 2.5 per cent of its research budget to the scheme. Each Ministry defines its research requirements and puts out an annual invitation to tender. SMEs bid to undertake the research with awards being made in two phases:

— Phase One. Up to $100,000 for a six month period to test the technical feasibility of the proposal and to demonstrate the company's ability to undertake R&D.

— Phase Two. Up to $750,000 to take the research up to the prototype stage. Applications have to demonstrate the potential commercial relevance of the research and, increasingly, that some conditional financial support from the private sector is available for Phase Three—taking the products to market.

The scheme is marketed and administered by Small Business Administration (SBA) through a simplified application process. It also provides business development support in Phase Three.

18. The UK equivalent is SMART and SPUR. However, there are several important contrasts.

— SBIR provides 100 per cent of project costs compared to 75 per cent for SMART and 50 per cent for SPUR awards. However, a SPUR follow-up grant is now automatic rather than competitive as with SBIR.

— The maximum amount of money per project is significantly higher under SBIR. The maximum SMART/SPUR grant is £157,000.

— Allowing for the difference in the population of the two countries, SBIR is on a larger scale than SMART/SPUR.

— SMART/SPUR are grants; SBIR is government procurement. As such it is not seen by government or companies as government assistance.

— SBIR provides funding at an earlier stage in the innovation process than does SMART. Initially it is less product specific and helps build up core technological competence within companies.

The majority of purchasing officers are satisfied with the research outputs under SBIR and, as a method of public procurement, its main costs are seen as limited additional administration. The scheme creates a market for SME research with companies perceiving benefits through the development of skills, hiring and retention of highly qualified staff, credibility with the financial community and the ability to work with external organisations such as universities.

19. SMART is a successful programme. In Scotland some 20 per cent of grants have gone to start-up companies and it helps meet early stage product development costs. However, it is relatively small scale. In the US, the SBIR programme is used extensively by SMEs and it has done much to develop the sectors R&D capabilities. While the IPR remains the property of the company, the research results become public knowledge. A similar UK programme could be a cost effective means of purchasing government research, providing job opportunities for scientists and technologists in SMEs and promoting innovation and the exploitation of science and technology.

The STTR Programme

20. The SBIR programme has promoted links between academia and technology based SMEs. Around 40 per cent of projects have some academic involvement. However, it was not designed to encourage such links. Based on SBA research showing academic interest and high rates of return from collaborative research, STTR was launched as a pilot programme in 1994. Modelled on the SBIR:

— Five Ministries (including the NSF) devote 0.5 per cent of their budget to the programme. In 1996 this represented a budget of $72 million.

— Awards are made in three phases in the same way as the SBIR programme, but

— Applications must be joint SME/Academic proposals with a minimum of 40 per cent of research being undertaken in the SME and 30 per cent in the research institute.

In contrast to the SBIR, this programme allows the principle researcher to retain his/her academic post. Consideration could be given to whether such a scheme would be an effective means of both developing and exploiting science and technology within the UK's SME sector.

Support for Technology Based Companies

21. Even in the world's most successful "high tech" regional economies such as Silicon Valley and Route 128 in the United States, only a very small proportion of new technology based companies achieve significant growth. To get more companies successfully growing through innovation and the exploitation of science and technology requires a large number of technology based start-ups. The number of such start-ups in Scotland is relatively low. Consequently, Scottish Enterprise believes policies and initiatives to increase the "high tech" business birth rate are crucial. These initiatives must be complimented by ones which provide support to enable them to survive and grow.

22. In addition to the suggestions made in the preceding paragraphs, the type of policies which would increase the number of technology based companies and their subsequent survival and growth include:

— Initiatives which encourage and enable new firm formation throughout the economy. It is unlikely that "high tech" entrepreneurship can exist in isolation. Technology based companies require the same basic infrastructure such as bank finance and managerial skills as other new starts as well as more specific high tech infrastructure such as venture capital.

— Informal support provided by successful high tech entrepreneurs. This may be more appropriate and effective than formal support through government schemes. In this context pump priming finance for mechanisms similar to the MIT Enterprise Forum could be effective. Scottish Enterprise, for example, supported the creation of a business forum in Scotland which is working well.

— Mechanisms which focus on the local environment and, more specifically, create and maintain the necessary local social and business networks (with connections to global networks). The local environment has an important effect on the start-up and growth of technology based companies.

— Assistance with entering non-UK markets. Entering non-UK markets is both essential and a problem for many technology based SMEs. Scottish Enterprise has a number of initiatives offering assistance. For example, the Scottish Export Assistance Scheme provides SMEs with seed corn finance to explore new overseas markets, the Virginia/Scotland partnership assists high tech companies generate sales, strategic alliances, licensing and distribution agreements with US companies while MatchMaker provides specialist trade missions, export advice and assistance for Scottish software companies.

High tech entrepreneurs require specialist technological and business development support. Scottish Enterprise provides this through, for example, its biotechnology team while some Local Enterprise Companies have specialist programmes. For example, Glasgow Development Agency Support Targeting Technology (a joint venture with Glasgow and Strathclyde Universities) which offers advice and management support to the area's technology based SMEs and entrepreneurs. In doing so, it uses both its own resources and, importantly, helps companies gain access to the many other sources of assistance which are available.

Closing Remarks

23. Scottish Enterprise sees innovation and the exploitation of science and technology as crucial to the future of the Scottish economy. As such it is a key component in its economic development strategy and a new team has been established to take forward the agenda set out in Technology Ventures and summarised in this submission. Success depends upon much more than government policy. Nevertheless, we believe the type of policy developments outlined in this submission would make an important contribution and encourage the active participation and commitment of the key players within the academic, business and financial communities.

January 1997

Memorandum by SmithKline Beecham Pharmaceuticals

Please find attached, for the Sub-Committees consideration, SmithKline Beecham's (SB) submission to the above enquiry.

As one of the world's leading healthcare companies, our ability to undertake R&D in a supportive environment is fundamental to SB's success. Last year we spent almost £660 million worldwide on R&D, over £250 million of which was spent in the UK. Within this total, £6 million was spent on UK university support for R&D, while over the past 10 years we have invested nearly £140 million worldwide into 75 early stage biomedical start-up companies and venture capital partnerships.

Our contribution is clear. In return we expect a strong UK science base. Unfortunately, we have doubts about the ability of the UK to continue to provide the necessary excellence in science and technology education needed to break through the innovation/exploitation barrier. We therefore welcome the opportunity afforded by this enquiry to air our concerns and to forward some possible solutions. SB would obviously be happy to expand upon them in oral evidence before the Committee.

1. Executive Sumamry.

UK competitiveness based on successful innovation is under threat as other countries grow their academic bases more quickly and are therefore better able to exploit R&D opportunities.

A huge number of Government initiatives are aimed at SMEs, often to the detriment of innovation. It should be remembered that larger companies are still responsible for over 70 per cent of the R&D in the UK; due emphasis should be given to their role.

On occasion the very number of Government initiatives is an obstacle to progress. There are too many schemes, too many contact points and therefore too many small pots of money to have any impact in isolation. Simplification is long overdue.

Adequate protection has to be afforded to private companies, such that they receive *reasonable* preferential access to the results of any joint collaboration with academia, and distinctive exploitation opportunities. Otherwise, there is no incentive to participate, in comparision with awaiting open publication in the literature.

The Government is working to too short a time-frame if it expects new products already from recent industry/academia collaborations. It should instead be looking for gradual and progressive improvement.

Academia is the most likely, and legitimate, source of totally new (ie unanticipated) opportunities and should not be overly restricted by demands for early exploitability. Academia must not become an ineffective mimic of industry's ability to commercialise new knowledge: this would serve neither community well.

SB would caution against the Government attempting to select "market winners" and propose instead a pragmatic enhancement of the strengths of the UK's successful "players".

The best stimulus to innovation is competition. Technologically averse or unaware SMEs fail, and should be allowed to do so, since their deficiencies often run deeper than mere cash-flow restrictions.

British industry needs a strong intellectual property system to encourage and safeguard innovation. SB would therefore wholeheartedly support the new EU proposal on the Legal Protection of Biotechnological Inventions.

2. Introduction

SmithKline Beecham (SB) welcomes this inquiry into exploiting the Innovation/Exploitation Barrier. As one of the world's leading healthcare companies, our ability to undertake R&D in a supportive environment is fundamental to our success. We are therefore grateful for this opportunity to submit our thoughts on this issue, and would welcome the chance of developing them before the Committee in an oral evidence session.

SB, along with others in the pharmaceutical industry, makes a strong contribution to R&D activity in this country. It is the UK's second highest spender on R&D—spending £653 million worldwide in 1995, over £230 million of which was in the UK. In total, the British Pharma Group companies (SB, Glaxo Wellcome and Zeneca) represent 26 per cent of all UK company R&D.

SB plays a significant part in supporting universities. We make considerable intellectual as well as financial contributions to major research liaisons, and fund state-of-the-art instrumentation in specific research collaborations when it is appropriate that the costs and benefits are shared by industry and academia. The total cost to R&D of our "university support" is £6 million per annum.

For over a decade, SB has also suported innovation via SR1, the company's venture capital subsidiary, through which we have invested nearly £140 million into 75 early stage biomedical start-up companies and venture capital partnerships. These partnerships have included the UK companies—Oxford Glycosciences, British Biotechnology, Electrosols, Cruachem, Xenova, Cambridge Antibody Technology and two of Abingworth's biotechnology venture partnerships. While these investments undoubtedly serve SB's strategic interests, they have the added benefit of stimulating entrepreneurship in the biomedical sciences and in developing and transferring academic technology into the commercial marketplace.

Our contribution is clear. In return we expect a strong UK science base. Unfortunately, we have doubts about the ability of the UK to continue to provide the necessary excellence in science and technology education needed to break through the innovation/exploitation barrier.

Against this background, SB welcomes the Sub-Committee's inquiry into The Innovation-Exploitation Barrier. Innovation in the UK is vitally important, both for wealth creation and for improved quality-of-life. Stimulating innovation involves many elements of society. We therefore applaud the Sub-Committee's attempt to address some of the key areas simultaneously.

3. Innovation in the UK

What is the current state of innovation in the United Kingdom?

3.1 A strong academic science base is important to the pharmaceutical industry, both to meet our need for well-qualified recruits, trained in modern technologies, and to allow effective collaboration with university departments. Unfortunately, UK competitiveness based on successful innovation is under threat as other countries grow their academic science bases more quickly and are therefore better able to exploit R&D opportunities. The reasons for this steady decline are many and varied, and are outlined below:

Science funding—too little is being spent, on both people and infrastructure; spending decisions are not transparent. Government is responsible for only 30 per cent of total spend on R&D. Public-private partnership is essential if international standards of research excellence are to be translated into improved competitiveness, but it is not the role of charities or industry to invest in infrastructure in the place of Government. The Private Finance Initiative is also not a credible alternative to Government funding.

University equipment—Funding of university equipment through the High Education Funding Council is on a steep downward curve. In 1996–97 expenditure on capital investment in universities will be cut by £107 million—a decrease in funding of 31 per cent, and while SB welcomed the Chancellor's allocation of £20 million for science equipment in his 1996 Budget, this extra funding will do little to resolve the significant problems of the science base.

Lack of Trained Personnel—many science graduates are not trained on modern equipment (automation, nuclear magnetic resonance spectrometry, mass spectrometry, molecular modelling). Problems in academic infrastructure (eg outdated equipment) create new costs (eg in remedial training) because science graduates are ill-prepared for work in laboratories. Lack of modern equipment not only disadvantages successful departments compared with their non-UK counterparts, but also makes collaboration with industry difficult. The resulting graduates have sound scientific knowledge but limited experience with modern laboratory equipment.

Courses—we find it difficult to recruit R&D candidates in the UK. Many courses, particularly in the biological disciplines (cellular biology, molecular genetics, bioinformatics) are not focused on the technologies we need. Chemistry is in a poor state, with too much emphasis on generalist courses. Universities must do more to obtain input on the relevance of course content and to adapt to the needs of business. In chemistry this means an emphasis on intellectual rigour in combination with modern laboratory skills and new technology. The structure of many courses is also inappropriate—only a proportion of science graduates need to complete courses that are intensive in laboratory techniques and research training.

Prioritisation—money is being spread too thinly and not sufficiently prioritised. Greater selectivity and a focus on excellence are essential. Not all universities are the same or can aspire to the same roles. Increasing international competitiveness demands greater selectivity and a focus on excellence. The reality is that the universities and the "old polytechnics" have different roles and that spreading research funding thinly across the whole spectrum works to the detriment of all.

3.2 SB would question the optimistic conclusions reached by the 1996 Research Assessment Exercise (RAE). It implies that research standards in UK Universities are rising and that the present funding system works. In reality, while biochemistry and perhaps pharmacology are national strengths, few other sciences are promising (chemistry emerges as dismal). There are a number of explanations for the RAE's conclusions.

First, the RAE is inevitably reactive rather than proactive and does little to address the issue of how to compare quality between different research disciplines. Because of the growth of the research transfer market, quality may have been delivered at an institution different to the one where it was measured. There are strong suspicions of a grade shift since the 1992 exercise, compounded by the behaviour of some universities to improve their apparent performance by manipulating the system.

The departmental focus of the RAE does not encourage collaborative work with other departments, disciplines, universities and industry generally. It is difficult to provide external validation and international comparisons in this rather introspective exercise but there is some evidence that the conclusions are not compatible with other findings.

As we understand the situation, once the university has received Higher Education Funding Council (HEFC) money it does not have to be distributed among departments in line with the RAE valuation ie. HEFC intentions to reward can be ignored. This is not sensible. If HEFC money is accepted it should be distributed in accordance with HEFC strategic intent. In addition, research focus should, arguably, be

promoted by introducing a prioritisation factor in the funding formula to reflect the agreed national importance of certain subjects.

3.3 In terms of patent filings and similar (admittedly imperfect) measures of innovation, the UK position is declining. Some argue that a relative decline is to be expected as "3rd World" countries establish a more up-to-date technological capability. This is a depressing perspective since it bodes ill for the UK's future economic prosperity if all we can hope for is a "pro rata" position based on population size.

3.4 The continuing decline in the perceived status of scientific study is a problem which is being addressed by science based industry and by the learned societies. However, this will continue to be an uphill battle whilst UK employment opportunities for qualified scientists remain poor.

4. Government Initiatives Designed to Stimulate Innovation

How successful have the Department of Trade and Industry and other Government Departments been with their range of initiatives designed to stimulate innovation?

4.1 The DTI and other Government Departments initiate a huge number of schemes to foster innovation, new businesses, etc. However, they are predominantly aimed at SMEs and start-ups, often to the actual detriment of innovation. The larger companies still undertake over 70 per cent of the R&D in this country, and the imbalance in Government support threatens the contributions to "national innovation" that companies like SB can make.

4.2 Synergy between research-based industry and academia is key to harnessing innovation successfully. The most successful schemes have been those which encourage this, such as the LINK scheme. SB has benefited directly from such schemes, for example in asymmetric synthesis, and our experience has been that the most valuable are those which generate discoveries in fundamental science, as these provide long term exploitability. However, the aim of most schemes appears to be to exploit existing innovations in order to gain "quick wins", which tends to duplicate something that industry is already capable of. We would also question current DTI thinking that all new LINKs require an SME to access the DTI money for the grant, as stated above, it is not always appropriate to have an SME in a collaboration.

4.3 On occasions, the very number of Government initiatives is an obstacle to progress. There are too many schemes, too many contact points, and therefore too many small pots of money to have any impact in isolation. There is too much running between multiple agencies to get anywhere, too much confusion about who to contact, too much incentive to give up and do something else. The recently announced project to combine schemes to radically simplify things is welcome—simplification is long overdue.

5. The Success of Industry/Academia Collaborations

How effective in terms of product or process innovation and other exploitable outcomes are initiatives which encourage collaboration between industry and academia?

5.1 The UK academic science base has become considerably more interactive with industry in the last few years and is far more businesslike in its accounting. However, long-term underfunding from central Government has meant that Universities are increasingly relying on industry to pay overheads of 40 per cent of salaries (increasing to 45 per cent from 1 April). In this way, the "intellectual" value and scope of such collaborations is being ever eroded.

5.2 The eagerness to be seen to be exploiting an invention can lead to an unrealistic patenting strategy on the part of universities, in which filings are made at too early a stage to fully protect the invention and with entirely unreasonable expectations of returns. Again, the effect is to inhibit rather than facilitate exploitation.

5.3 Where partnerships with the private sector are constructed (eg within Framework Programme consortia, or in national initiatives such as LINK in the UK), adequate protection has to be afforded to the investments made by participating companies. For example, they should receive reasonable preferential access to the results of the project, and distinctive exploitation opportunities. Otherwise, there is no incentive to participate, in comparison with awaiting open publication in the literature. The potential conflict of interest between the greater dissemination of results and legitimate business interests must be addressed transparently.

5.4 SB would question the ease of measuring objectively the success or otherwise of initiatives designed to encourage collaboration between industry and academia. The Government is perhaps working to too short a time-frame if it expects new products already from recent collaborations. It should instead be looking for a gradual and progressive improvement in the capture of academic creativity in innovative products, as the "ethos" changes in numerous ways, not a sudden dramatic upturn.

5.3 Promoting people exchanges between industry and academia would perhaps have the greatest (positive) effect in overcoming the residual barriers. However, this is not likely to happen regularly because an industry-to-academia move means such a huge drop in salary and working conditions (plus uncertainty about the chances of a subsequent return). No amount of "quick-fix" initiatives will overcome that obstacle—it represents a fundamental infrastructure/investment issue.

In the academic sector, rapid reversal of decline cannot be realistically expected. It requires long-term commitment and investment by Government and a commitment by the universities to adopt more disciplined governance. The need for selectivity in academic funding to support research excellence is accepted. But, perceptions differ widely on how selectivity should operate. Is it an appropriate generalisation to suppose that most new universities aspire to emulate Oxbridge? Selective funding is a major issue when all universities bid to do research and false egalitarianism in distribution of scarce funds is a prescription for widespread decline.

5.4 It should be clearly understood that the creative community comprises academia and industry (SMEs and larger companies), but that academia is the most likely, and legitimate, source of totally new (ie unanticipated) opportunities and should not be overly restricted by demands for early exploitability.

6. Financing

Does financing need to be improved for technology-based small firms during their crucial start-up and early development phases?

6.1 Following damage to the vitality of small and medium enterprises (SMEs) caused by the last recession, the UK is again beginning to furnish a more hospitable environment for new ventures. The inception of the Alternative Investment Market has encouraged start-up companies, but there remains a problem in raising initial funds.

Despite this improvement, however, there remains an unquestionable need for increasing the proportion of the public purse (or total GDP) devoted to R&D. But it should be accompanied by more efficient use of resources, with greater priority given to excellence. Thus, "more" should not uncritically be equated with "better". In this regard, the UK would do well to focus the broad thrust of its public R&D budget preferentially on those areas for which its industries are internationally competitive or within realistic reach of becoming so.

6.2 We would caution against the Government attempting to select "market winners", an exercise that in general has an unimpressive historical track-record. We propose instead a pragmatic enhancement of the strengths of the UK's succesful "players"—industries such as the chemicals and pharmaceuticals sectors which are world-class. Competing in "high growth potential" markets without a realistic evaluation of the UK's capacity to achieve leadership world-wide is an irresponsible diversion of resources and innovative skill.

6.3 One of the useful functions of the DTI initiatives has been to bring together small firms, eg instrument manufacturers, and the industries who are the ultimate users of their products. This ensures access to markets for exploitable ideas but still leaves the small firm to fund their R&D investment. In this way, SB regards the many SMEs in our own sector, predominantly but not exclusively biotechnology companies and ventures developing other technologies, as essential co-contributors to sector innovation, and often as scientific and business partners.

However, we cannot support any policies that seek to promote SME interests and capabilities but which act to the detriment of larger companies with proven track-records for successful innovation and commercial exploitation. The growing focus on SMEs as apparently the sole means of converting research into (commercial) innovation is wholly unbalanced and unjustified.

6.4 We also challenge the notion that SMEs and the technologically averse sectors of UK industry can effectively be provoked into far-sighted attitudes to R&D by direct governmental action, and least of all through subsidy or technology transfer schemes. The best stimulus to innovation is competition. In the healthcare sector, for example, technologically competent SMEs prosper and frequently enhance the abilities of larger business partners and, given an improved venture capital and financial environment, can win new financing on the strengths of their ideas and early results. Technologically averse or unaware SMEs fail, and should be allowed to do so, since their deficiencies often run deeper than more cash-flow restrictions.

6.5 As an alternative to the conventional practice of academia spawning start-up companies, the next stage in the enterprise culture is likely to be driven equally by initiatives arising from big companies in which excess assets will throw up start-up companies, possibly nucleated and incubated within the facility of the parent company.

7. Alternative Support for Innovation?

What other support systems could be introduced to ensure that the maximum advantage is taken of innovative ideas that originate with individuals or, for example, in academia?

7.1 The question implies that industry's role is to exploit ideas from academia and other independent individuals. There seems little recognition from the phraseology that many innovations originate from industry and that a frequent role for academia is to learn more, at industry's request (collaborative and contract research formats) about the new opportunity. The central dogma that the UK is good at generating new ideas, but poor at exploiting them, is both difficult to reconcile with the (admittedly few) UK successful industries, eg pharmaceuticals, defence, chemicals; and again reinforces the simplistic view that it is all industry's fault and/or all that is needed is a better "handover" mechanism. A more holistic approach is

required, not least through ensuring that the science and technology base, in academia or industry, is supported to the maximum affordable extent as a priority investment. A small isolated and poorly equipped laboratory will be less creative/innovative than a more coherent, well-founded centre of excellence, even if the latter can only be afforded by closing down many of the smaller uncompetitive centres. The notion that a few tweaks here and there will have a huge impact is delusional.

7.2 Academia's freedom and competence to explore wholly new areas without any contemporary evidence of commercial potential has always been, and will continue to be, a potent contribution to the overall innovative capabilities of society. This cannot be achieved without accepting a high degree of uncertainty and unpredictability in the outcome of any new research initiative. Having academics focus excessively on shorter-term (safe) objectives with greater assurance of commercial application would rapidly destroy this essential "blue skies" scanning, and so cripple industry's ability to convert this new knowledge into new products.

7.3 Academia must not become an ineffective mimic of industry's ability to commercialise new knowledge: this would serve neither community well. Both sectors can contribute in partnership. This would by-pass the criticism that UK focuses too much on fundamental research at the expense of research leading to new products: rather, if flexibly aligned, one is the essential basis of the other.

7.4 The NHS harbours an unmatched resource for life sciences R&D. Approximately 65 million patients are detailed on its database—information which, if assessed systematically, could considerably enhance our understanding of disease processes, the benefits of health care interventions controlled for individual risk. Over 90 per cent of GPs are now linked in by computer, potentially representing a prototype system for the application of large scale population based healthcare informatics. Currently available computer software systems can accommodate the different soft and hardware systems used by participating GPs, allowing data to be transformed into a common format. However, this resource remains under utilised, as the UK fails to adopt coherent policies that link science and medicine across all government departments. Political pressures should be brought to bear to make NHS R&D more closely linked with the research community. NHS R&D initiatives are fragmented (eg UK Clearing House on Health Care Outcomes, Cochrane Collaboration, Promoting Clinical Effectiveness) which if integrated and supported by the appropriate IT systems offer considerable opportunity for research collaboration with the research community.

8. Institutional Support for Innovation

Is there institutional inertia towards the funding of technology-based small companies? If so, to what extent may this be due to financiers' unfamiliarity with science and technology concepts and what should be done to address this?

8.1 The inertia described above most definitely exists. However, unfamiliarity with S&T is not purely a financier's problem. Until recently there have been few signs that Government understood the relationships between research in the science base, university teaching and research training, the advance of knowledge and the broader needs of society and government. However, it is fair to acknowledge that the UK's political parties are beginning now to recognise the difficulties facing science. For example, SB particularly welcomed the recent creation of a Whitehall Working Group, which has brought together representatives from all key departments to consider the science base. This cross-departmental coherence is crucial, as research and innovation issues cannot be decoupled from regulatory statute, training, policy management and financial issues.

9. Tax Credits and R&D

The Committee recommended tax credits for research and development in our previous enquiry. Would this still be an effective way of fostering innovation and how should they be introduced to ensure that they are roughly cost-neutral?

9.1 SB would like to see continuance of tax benefits offered for work carried out on R&D activities. Naturally, government assistance does not in itself give rise to innovation, whether by way of tax relief, or direct subsidy. However, it may be helpful in creating the right climate for innovation.

9.2 However, while more tax breaks for R&D spending would be useful, the concept of cost neutrality presents various problems. In our view the timescales used to make this judgement are unrealistically short and the Treasury needs to make a similar act of faith to that used for education funding. There are elements of risk; the outcome for any given initiative is not guaranteed. However, in the long run the successfully developed initiatives will more than compensate in terms of tax revenue, increased employment, etc.

9.3 One particular idea that might be worth developing is the proposal by biotechnology companies to offset corporation tax losses as a credit against their employee withholding tax obligations. Many biotechnology companies have accumulated large tax losses which they will obviously wish to recoup sooner rather than later. This transfer of economic benefits via the tax system may be used as a seedcorn proposal to assist such companies with their cash flow. SB tentatively supports this as it may ultimately mean more realistic milestone payments on agreements between major players and these companies, often SMEs, to mutual benefit in terms of fostering innovation.

10. Technology Foresight

How has the Technology Foresight Exercise influenced the availability of development funds for innovative ideas that were not given short-term high priority status?

10.1 SB welcomed the Technology Foresight (TF) exercise and strongly agreed with the principle of building partnerships. It represented the most comprehensive inventory of national science and technology assets in three decades.

10.2 We agreed with the TF Steering Group that life sciences research should be the top priority for the UK, a country which enjoys both the scientific and commercial resources to harness excellence in the life sciences for improved health and wealth creation. We are however, concerned at the loss in momentum following the production of the Panel Reports, and most important, we do not believe that there has been effective prioritisation as an output from the exercise.

10.3 There is little evidence that Foresight has made any difference beyond the Challenge Fund and similar "short term" initiatives (eg increased LINK funding): However, it may be too early to expect a clear tide of new products from TF. And many things may be difficult to attribute overtly to TF or to TF alone—so the issue of sensible measurement arises. Have any industries that were not already heavy R&D investors (and therefore already a "persuaded audience") increased their investments in the future because of TF?

10.4 We doubt that the long-term outcome of TF will have greater impact on innovation than simply funding the best initiatives without constraining them to specified areas of science. This is partly because of the long gestation period for the TF exercise, which almost guarantees that it will be out of date before the returns are realised, and partly because there has to be room for serendipity in original research.

10.5 The true long-term value of TF is unlikely to lie primarily in agreeing lists of critical technologies but more in the process of building partnerships among the different constituencies.

11. Tax Relief and Vocational Training

Has the tax relief introduced in 1992–93 for individuals' expenditure on vocational training had any impact on the status of continuing professional development, in particular for employees in small firms?

11.1 Since vocational training within employment will often/normally be paid for by the employer, this tax relief can all too frequently be irrelevant. Furthermore, to delegate it to individuals is unrealistic—if they pay as individuals, they are unlikely to be getting support (ie time off) from their employers, so there will be a real tension between the perceived benefits to employee and employer.

11.2 Tax relief for individuals' vocational training whilst unemployed might make more sense in this regard, but, of course, these are the people least well-placed to invest in the future, and with perhaps the most legitimate expectation of public sector support for retraining.

12. The Importance of Intellectual and Industrial Property

12.1 No analysis of The Innovation/Exploitation Barrier would be complete without recognising the need for a strong intellectual property system in promoting innovation in the UK.

12.2 Patents encourage innovation. They offer the reward of commercial exclusivity necessary to encourage investors to fund expensive, long-term and high-risk areas of research. Patents also encourage openness as a patent cannot be granted unless the inventor gives to the public a clear and complete description of the invention.

12.3 The European Commission has identified effective patent legislation (harmonised at the European level) as a major element in innovative R&D, European competitiveness and economic and social growth. It has therefore proposed a revised Directive on Legal Protection of Biotechnological Inventions which SB fully supports (but strictly on the basis of its present wording). The current wording will achieve a levelling up of patent protection to that of the strongest existing national codes. However, it is finely balanced and any amendment to it could easily result in legislation detrimental to strong patent protection for biotechnology products and an unacceptable barrier to innovation.

12.4 Through its industry, universities and research institutes, Britain is the leading centre of biotechnology research in Europe and has the most to gain from the successful implementation of the Directive. Industry, while recognising the limitations of the Directive, believes it will help to foster an environment in which European innovation can catch up with the United States and Japan, and help attract further research and development for Britain.

12.5 If the EU fails to implement acceptable pan-European legislation, it would mean that intellectual property for biotechnological inventions may be protected in some markets but not in others. This will have a major impact not just on the pharmaceutical industry, but on the funding of scientific research and innovation as a whole.

13. CONCLUSION

13.1 Government action to sustain competitiveness and innovation in life sciences is an imperative. Creating an enduring, supportive climate for R&D is problematic because of insufficient appreciation of scientific issues in Government, because of the competing fiscal pressures in the national budget and because of the need to reduce public expenditure as a short-term political expediency. Nonetheless, it is important to identify and correct previous mistakes in strategic funding with a view to re-prioritising Government spending, investing in "winners" and reversing the desperate decline in the UK's science base.

13.2 Ultimately, the best stimulus to innovation is competition. While the large proportion of UK businesses that are SMEs is a valid argument for overt attention to the needs of these enterprises, we would also point to the reality that large enterprises still employ nearly a third of Europe's work-force, with very many more jobs (and SMEs themselves) depending indirectly on the continued prosperity of such large companies. Europe must not build its potential powerhouses of the future at the expense of its current major wealth creators. Far too many of Europe's SMEs are "low-tech", whereas many of the Union's most successful large companies are 'high-tech", and thus offer better and more sustainable prospects in an increasingly technological future.

Dr. George Poste, Chairman, Research and Development

16 January 1997

Memorandum by Dr Fiona Steele, Director, Economic and Social Research Council Innovation Research Programme

Precis

This short paper encourages the Committee to adopt a broader canvas in its enquiry into "The Innovation-Exploitation Barrier" and include in its study consideration of the "people-related" issues which dominate all aspects of the innovation process. The contribution of social science and management research towards obtaining a deeper understanding of these issues is becoming increasingly recognised, and this note includes some examples of where barriers to innovation are seen to lie and how the Economic and Social Research Council in particular is tackling them via its innovation activities. Suggestions, while based on the experience of social science but certainly not exclusive to it, are also made for improving communication between academia and the business communities and therefore encouraging greater collaboration between them.

A Need for a more Holistic Approach to Tackling the Innovation Exploitation Barrier

This note draws out the more intangible or "soft" human issues which are increasingly recognised as being of as much importance to successful innovation as the development of tangible or "hard" products and processes. These "human-centred" factors, while being frequently referenced, not least in the Bank of England report on *The Financing of Technology-based Small Firms* which forms the context of the Committee's enquiry (and which is peppered with references to managerial shortcomings on the part of would-be and existing entrepreneurs(1), have tended to be skated over in previous discussions of barriers to innovation and have not received the attention they deserve.

This House of Lords enquiry has a particularly timely opportunity to go beyond a preoccupation with well-documented traditional barriers to innovation such as lack of finance, short-termism by financial institutions, insufficient research and development, inadequate Government incentives, etc and explore in more detail the cultural and organisational factors which may inhibit the take-up of the many innovative ideas which are continually being generated. It is suggested therefore that the Committee might also wish to review how this, admittedly more difficult to get a handle on, aspect is being tackled and how it might be encouraged. It is also an aspect where there is considerably more scope for a closer accommodation between the work of social science and management researchers in academia and the concerns of business. This note therefore does not tackle the questions in the Committee's call for evidence one by one but lies in the general context of a number of them and goes beyond to take a more holistic and "softer" view of the innovation process.

Government Initiatives

The Technology Foresight exercise itself revealed the importance of increased attention to business processes in making the link between the opportunities offered by science and technology and market needs, and this was listed as one of the main priorities for action(2). The Economic and Social Research Council, following on from the publication of the "Realising our Potential" and first "Competitiveness" White Papers had already identified Innovation, Organisations and Business Processes as one of its thematic priorities and recognised that the particular skills of its constituents in the social and management sciences could fruitfully be brought to bear on these issues. It has set in train a number of activities including the setting up of three Research Centres devoted to various aspects of innovation, a Business Processes Resource Centre to act as

a best practice repository of information and route to defining research agendas, and a dedicated multi-centre research programme to investigate the innovative management of innovation. Some £12 million of funding is invested in these initiatives and the strong involvement of the "user" is regarded as essential.

The ESRC's Innovation Programme

The Committee may wish to look at this programme, which covers the role of innovative management in the achievement of sustained improvement in the bottom line performance of commercial, quasi-commercial public sector and industrial businesses, as a model for developing a shared interest between business and academia. It is an example of how users can take advantage of the deeper insight that rigorous academic analysis can bring to the study of the managerial processes and techniques which need to be put in place to support the competitiveness of organisations in a fast-changing marketplace. It is very much about research on business in business and is informed by a "business wishlist" of research questions relating to human-centred issues. Many of these are sector and size-independent and the individual experiences of the different academic/user collaborations have a wider resonance—an objective of the Programme is to make this experience available to each other and to the broader user community.

It is also important, given that innovation is a dynamic process, that such research should be flexible in its approach and thus the "business wishlist" associated with it should be continually updated. It was certainly an innovation for the ESRC that the traditional method of calling for proposals was accompanied formally by such a "wishlist" and this is attached as Annex 1 to give the Committee a flavour of the "human-centred" questions regarded by the business community at the time (January 1996) as being "barriers" to successful innovation. The current agenda is developing as shown in Annex 2.

The Communication Barrier

While the business community is encouraging academic researchers to tackle these issues by direct involvement in the Innovation Programme, and there is a strong willingness by the academics to research them, a really close meeting of minds is still being hampered by a "language" barrier. The traditional method of recognising academic performance through the quality of papers in academic "language" in peer-reviewed academic journals is still dominant, encouraged by the demands of the Research Assessment Exercise and its league tables based on such papers. A recent debate organised by the Programme involving both academics and users suggested that a much wider range of recognition measures should be adopted (summarised in Annex 3) and the Committee, in the context of the third question in its call for evidence, may wish to note these as suggestions for a more effective relationship between academia and business. There is no reason why business relevance and academic excellence cannot be compatible, and this writer believes that real added value will only come from the HEI system by application of such a twin-track approach to funding. It would also contribute to the necessary more holistic approach to making the innovation process more effective and is of course not confined to social science research.

Conclusions

The UK's difficulties in exploiting the ideas generated by its population have so frequently been attributed to having the "wrong culture" but most recommendations for action still tend to focus on "hard" rather than "soft" solutions. A much greater understanding of the "people"-related issues, and particularly a determined effort to identify shared interests and seek a common language in tackling the issues they raise would help to overcome many of the "barriers" that are perceived to inhibit successful innovation. The ESRC is certainly very conscious of the increasingly important role it can play in helping to solve such problems.

January 1997

References

(1) *The Financing of Technology-based Small Firms,* Bank of England, October 1996—"Poor management skills of the founder and reluctance to build a stronger management team has been identified as one of the main reasons for early stage technology-based firms failing to obtain external finance". (para 2.7)

"Management ability is a key factor in the investment decision of a venture capital firm and lack of it is one of the main reasons why a project may be rejected." (para 3.32)

"Investors are more likely to lose money in technology-based firms because of 'people factors' than as a result of the failure of the technology or the absence of a market." (para 3.35)

and, in the summary recommendations in the report

"Improve management skills to encourage finance providers."

(2) *Progress through Partnership*—Report from the Steering Group of the Technology Foresight Programme 1995. Office of Science and Technology.

Annex 1

INNOVATION PROGRAMME PHASE 2

RESEARCH QUESTIONS—A BUSINESS WISH LIST, January 1996

LINKING STRATEGY WITH IMPLEMENTATION

Markets

How to encourage innovation in directions which have real market/commercial value.

How to develop and manage a closer symbiotic relationship between customer and supplier in the innovation process.

How to turn a market that sees regulation and standardisation as a threat to one that sees these as an opportunity.

How to do business in different cultures.

Creativity

How to improve the creative, innovative processes of the brain.

How to encourage creativity and risk-taking while reducing the odds of failure.

How to encourage a set of behaviours which will provide a natural disposition towards innovation and how these differ from behaviours needed to implement innovation.

How to develop behaviours that nurture and sustain, through all levels of management, innovation arising at the coal face.

How to spot the good idea which will generate a following, recognising that the idea generator may not be the right person to carry it through, and therefore how to identify the leader/project champion to drive it through to realisation.

How to define a topology of innovation so that organisations can determine the right approaches and solutions for their particular situations.

How not to homogenise out the passion.

Competence

How to define core competencies and the skills needed to pursue these within a defined company "architecture" and how to preserve the capability.

How to raise competence capability against that of the competition.

How to avoid the competence trap of perpetuating what you are good at rather than what is needed to adapt to the changing business requirements.

How to decide what competencies should be sourced internally and what extramurally.

Structure

How to handle the "dynamics of rapid change" including complexity and uncertainty.

How to handle "people" issues when introducing new concepts and ways of working such as:

- How to let go of existing entrenched ways of working;
- What tools will facilitate achieving acceptability and commitment at all levels identifying the right communication channels and key people, and how to achieve a balance between the commitment gained when people think and find out about things themselves and the response to more formal communication channels;
- How to address the gap between what people think they need and what they actually need.

How to manage the "virtual" company and the human relations implications of the fundamental insecurity engendered when groups within and between companies come together for specific projects, disband and reform in new directions.

What are the innovation management responses which will encourage innovation following major structural changes such as privatisation, merger and demerger, leveraged buy-out etc.

Dissemination

How can we use better the information that is already available from academic research and identify what really matters.

Annex 2

RESEARCH QUESTIONS—A BUSINESS WISHLIST, JANUARY 1997

HOT TOPICS

Markets

Managing new forms of relationships with customers and within the supply chain.

Creativity

Increased insecurity and changes in traditional relationships between employer and employee and the effect that this might have on creativity and innovativeness—are employees being left behind in the rush to change processes and structure?

Competence

Downsizing and outsourcing and the effect these have on the loss of corporate memory and how they affect the identification of the core competences which must be retained in-house.

Managing the influence and use of information technology.

How to persuade companies of the need to be "foresighted" in their strategic planning?

Structure

The effect of empowerment of employees and flattened management hierarchies—what does empowerment really mean in practice?

Are teams really effective?
The need for new forms of performance measures that can accommodate rapid change.

How generic are the themes of Business Process Re-Engineering and are they applicable across all types of organisation?

When and how to use the new tools for "policy deployment".

Annex 3

ACHIEVING A CLOSER ACCOMMODATION BETWEEN ACADEMIA AND THE BUSINESS COMMUNITY

Suggested measures

Users should be involved in research design and selection, on-line in reviewing progress, and subsequently in its evaluation; and brokers should be identified with clear liaison roles.

Effectiveness in collaboration and dissemination should be made as important as scientific quality in both the selection and the evaluation process.

Greater use should be made of staged projects to develop user interest and commitment.

Equal prominence should be given in reward systems to successful collaboration with users.

Successful case studies of academic/user collaboration of different types should be identified as role models to encourage wider involvement.

Brokers should be identified to build networks to share experience, and journalists should be brought in to spread messages in a user-friendly way.

The continued development of the Teaching Company Scheme and Postgraduate Training Partnerships should be encouraged.

Post-experience courses should be encouraged as a basis for positive relationship-building.

Wider use should be made of electronic publishing to speed up the transmission of research results into a form which can be assimilated by users and intermediaries such as consultants and for use in HEI training material.

Memorandum by St John's Innovation Centre, Cambridge

The scale of the growth in the Cambridge area over the last 20 years of the telecommunications, software, biotechnology and advanced industries is unique in Europe. 1,200 new businesses have been established, 25,000 new jobs directly created and the total turnover of the new businesses in these industries is between £1.5 and £2.0 billion per annum. The only comparable development is at Sophie Antipolis on the French Riviera which is similar in terms of employment and number of companies but results from billions of francs national investment to attract businesses into the region. The Sophie Antipolis development has been well publicised, the Cambridge "Phenomenon" is by comparison little known outside academic circles.

The St John's Innovation Centre was established in 1987 by St John's College Cambridge as an incubator to help early stage indigenous technology based businesses "survive and thrive". We are not and never have been in receipt of any government funding, and our shareholders expect us to operate on a purely commercial basis. At the end of 1996 the Park is occupied by 64 companies almost all of whom are under 5 years old. Over 1,000 people are employed on the site and total turnover of tenant companies is in excess of £30 million per annum.

Our views are coloured by our background and experience in what is apparently a successful environment. In response to your call for evidence:

Current State of Innovation in the UK

Our perception at grass roots level is that in a European context we are currently well placed particularly in the biotechnology and telecommunications sectors. We would however regard the United States as our role model. It is difficult to replicate the US experience however because our culture and particulary our attitude to risk taking is different. We do not appear to be short of ideas which can be commercially exploited, the problem seems to be in funding at the start up and exit stage. Too often firms seem to pass to foreign, particularly US, ownership.

DTI Initiatives

There still seem to be far too many initiatives for SMEs to cope with. Our experience is also that the DTI sometimes does not always work well with Business Links in trying to get new initiatives "off the ground" on a local basis. Often the right hand does not appear to know what the left hand is doing and on occasions the process becomes too bureaucratic and misunderstandings arise. However, in recent years the DTI regionally appears to have adopted a more positive (and helpful) approach and new initiatives such as BMB are to be welcomed.

Given the number of good ideas in the Cambridge area we believe that, on merit the East Region is still not receiving a fair share of SMART/SPUR awards.

Industry/Academia Collaboration

The Teaching Company Scheme is very useful but may perhaps be under-used.

The research that has been carried out on a local basis would seem to indicate that Cambridge University is not a good collaborator with SMEs. Local business people seem to collaborate with other Universities with greater ease but formal collaboration with Cambridge itself is difficult (see recent CEST Report produced for DTI on Biotechnology in East Region). Nationally Industrial Liaison Offices appear to be underfunded and under resourced for what they are trying to achieve.

Financing of technology based small firms during start up and early stage development

Locally the CRIL and Quantum Funds are involved in Seed Finance and in total make around 8 seed investments per annum. Neither fund can afford to employ more staff and have been unable to persuade their investors that an additional investment in staff is worthwhile. The management of both funds believe that properly resourced they would be able to make twice the number of investments per annum without diluting existing criteria. We would argue that it is in the national interest that more government support is available to such funds to enable them to recruit the additional quality staff they need.

We would like to see stronger links, between Banks/Innovation Centres/Business Links/TECs in providing management training to businesses and in assisting businesses with problems.

Support Systems for Individuals and Academia

We believe that the success of incubators such as the St John's Innovation Centre, shows what can be done to create a supportive environment. However we are totally commercial and do not enjoy any direct subsidiary so we are unable therefore to provide some services which are clearly needed but which businesses cannot afford to pay for.

We believe it to be in the national interest that genuine aspirational start ups are supported by UK government and it is irrelevant whether such start ups are in Cambridge or Liverpool. Early stage businesses cannot afford proper support and advice particularly in finance and marketing. The Enterprise Agencies do not have the skills to support such businesses and the Business Links are in a different market place. We believe therefore that it is important that there be a consistency of approach between Innovation Centres such as ourselves and Business Links to provide such subsidized services, and that Innovation Centres such as ours even in non priority areas should receive direct support to enable them to provide a full range of services where specific needs can be demonstrated.

Inertia towards funding of technology based businesses?

In our experience it is the attitude towards risk—"early stage", "market and/or technology not proven" that is the problem rather than the need to actually understand the technology. In practice, it is possible to check out the technical capabilities of individuals quite easily. To assist in financing more specialist Funds (eg Quantum) are needed, corporate venturing should be encouraged (exploitation of small companies by the larger venturer is however a real problem), as should regional Financial Support and Business Angel networks targeted at assisting early stage technology based businesses.

What we are experiencing in Cambridge is being replicated in the East Anglia Region. Over the past few months we have been contracted by a number of business people from the Region looking to fund new ideas and who have drawn a blank in their own areas. Business Links in Peterborough Suffolk, Norfolk and more recently St Albans have called upon our support to help some of their local entrepreneurs. We are keen to help but our time needs to be paid for, and there is a limit to what we can do, "probono".

Tax Credits

Tax credits for research and development should be encouraged. The problem with most of our clients however is that they are not making profits in their early years.

Technology Foresight

At the level in which we operate this exercise has not made any noticeable difference.

Tax relief on vocational training

In Cambridge everyone seems very cynical about their employer whatever the type of company, yet we have not noticed any increase in the demand for vocational training despite the tax inducement, in any of the companies we come into contact with. We ourselves are very disappointed at our own staff's attitude to vocational training although this probably says more about ourselves than our staff.

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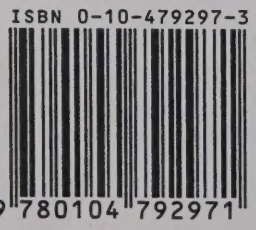

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